FINAL REPORT TO TRANSPORT CANADA

EVALUATION OF POTENTIAL IMPROVEMENTS IN AUTOMOBILE FUEL CONSUMPTION AT LOW TEMPERATURES

PHASE I

VOLUME I - MAIN BODY

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ABSTRACT

A study was undertaken to evaluate the improvements in fuel consumption and driveability of automobiles incorporating modifications designed to improve low temperature performance. In the study, three Omni/horizon 1.7 L vehicles incorporating the following modifications were evaluated:

- early fuel evaporation (EFE)
- engine block heat conservation
- high compression
- engine block heater

Comparative fuel consumption evaluations were carried out on a chassis dynamometer following the procedures of the Transport Canada city and highway driving cycles over a range of temperatures from - 20°C (-4°F) to +25°C (77°F). Driveability evaluations were carried out on a test track over a range of temperatures from -25°C (-13°F) to 25°C (77°F) using a Chrysler rating procedure.

Test results indicated that the engine block heat conservation modifications provided the greatest overall improvement in fuel consumption at low temperatures. Compared with the base vehicle, the improvement was 8% for the city cycle and 9% for the highway cycle at a test temperature of -20°C (-4°F). This vehicle configuration also significantly lengthened the cool-down time of the engine during cold soak, as well as reducing engine warm-up time after a cold start at cold temperatures.

An increase in compression ratio of an unmodified test vehicle from 8.23:1 to 9.52:1 provided city and highway fuel consumption improvement of 4% to 8% over the base car at all test temperatures.

The EFE modification provided significant improvements in the city cycle fuel consumption at -20°C (-4°F) (18% for bag 1 and 6% overall) with a 1% improvement at 0°C (32°F) but a 4% penalty at 25°C (77°F). Highway cycle fuel consumption was not significantly affected at any test temperature with the EFE configuration.

The optimum block heater preheat time for the best fuel consumption after a cold start was determined to be in the region of 2½ hours. The fuel consumption improvement was approximately 10% for the city cycle at a test temperature of -20°C (-4°F) over the base vehicle.

The greatest improvement in vehicle driveability was obtained with the use of an engine block heater prior to a cold start. The vehicle modifications per se generally had negligible effects on the vehicle driveability ratings other than improving the initial idle quality in the case of the EFE modifications.

1.0 INTRODUCTION

1.1 Background

The optimization of fuel consumption and driveability charteristics of automobile engines at low temperatures is important to satisfy Canada's energy conservation goals, as well as the driving expectations of the general public. Current practice for rating new production vehicles is to obtain vehicle fuel consumption at test temperatures between 20°C (77°F) and 30°C (94°F) inclusive. Although it is known that the fuel consumption rate tends to increase during low ambient temperature operation of a vehicle, the extent of the increase in relation to a specific portion of the Federal City and Highway Driving Cycle is not well known. Perhaps even more important is the limited number of studies directed at improving this low temperature performance of automobiles.

Several areas of technical modification to an automobile engine to provide improved fuel efficiency at low temperature were proposed by Chrysler Canada Ltd. for test evaluation. In conjunction with Transport Canada and Chrysler Canada, Davis Engineering Limited, under contract no. OST80-00058 with the Road and Motor Vehicle Traffic Safety Branch of Transport Canada, undertook a test program to evaluate the proposed modifications.

Omni/Horizon vehicles incorporating several engine modifications, were subjected to a series of chassis dynamometer tests in a cold chamber such that the fuel consumption characteristics on standard reference driving cycles (FTP City and Highway) could be compared at different temperatures for base (unmodified) and modified engines.

In addition to the reference dynamometer tests, each of these modified vehicles was subjected to test track driveability evaluation in a range of temperatures from 25°C (77°F) to -25°C (-13°F), as the weather permitted.

This program was conducted at the Transport Canada Motor Vehicle Test Centre in Blainville, Quebec during the period between October, 1980 and April, 1981.

1.2 Objectives

The objective of this project was to assess the fuel consumption and driveability performance of Omni/Horizon vehicles having a number of engine modifications intended to improve low temperature performance. This assessment was carried out by comparing the performance of a "standard" engine with that of engine configurations incorporating the following principal engine modifications:

(1) early fuel evaporation;
(2) engine block heat conservation; and,
(3) high compression.

1.3 Scope

The scope of this project was limited to assessing the fuel consumption and driveability performance of the engine configurations given in the objectives (Section 1.2).

The temperature range over which the assessment was carried out was nominally from 25°C (77°F) to -20°C (-4°F), although the temperatures for the driveability tests were dictated by the outside ambient weather conditions at the time of testing.

The fuel consumption measurements were made gravimetrically following Transport Canada procedures. Repeatability of results was ensured by:

- weekly scheduled maintenance and tuning of the test vehicles;
- scheduled calibration of the test instrumentation; and,
- repetition of test runs; from two to four tests were carried out per vehicle at each test point.

1.4 Report Layout

This report is divided into three volumes. Volume 1, which contains the main body of the report, summarizes all of the equipment used and test procedures followed during the program. In addition, test results are presented and discussed and conclusions are drawn. Volume 2 contains copies of fuel consumption and temperature traces for all of the selected runs. Appendices 1-12 are contained in Volume 3. The raw test data from all fuel consumption tests, driveability runs, weekly scheduled maintenance and dynamometer RLPC calibrations are stored on file at Transport Canada.

2.0 EQUIPMENT/INSTRUMENTATION/FACILITIES

2.1 Test Vehicles

Three test vehicles were used in the program. They were 1980 Canadian Omni/Horizon vehicles with 1.7 litre 4 cylinder engines and three-speed automatic transmissions. All vehicles were fitted with 1979 Canadian production ignition, carburation and exhaust gas recirculation (EGR) systems. Use of the 1979 ignition system with its integral electronic spark control computer (not used in 1980) allowed use of prototype spark control computers which would not have been compatible with the 1980 ignition system.

Two vehicles were four-door sedan models while the third was a two-door model. However, all vehicles were tested as four-door models with respect to the test parameters of road load horsepower and equivalent test weight.

Table 1 lists the test vehicles and identifies the relationship between the vehicle number, VIN, and configuration number.

All vehicles were tested at an inertia weight of 1130 kg (2,500 lb.) and road load power 5.9 kw* (7.9 H.P.).

2.2 Gravimetric Fuel Consumption Measurement System

The vehicle fuel consumption during chassis dynamometer testing was determined gravimetrically. A fuel supply system was developed which functionally simulated as closely as possible the operational characteristics of the original equipment manufacturer (OEM) fuel supply system. A schematic diagram of the system is shown in Figure 1.

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* Except as indicated in Sections 3.7 and 5.2.2.2

Figures 2 and 3 illustrate the instrument room portion and the vehicle under hood portions of the fuel system,respectively. The following is a description of the system and its operational modes.

2.2.1 Components of the Gravimetric Fuel Consumption System

The precision weigh scale measures the weight of fuel consumed by a test vehicle to the nearest gram. It is interfaced to the datalogger which provides a permanent record of the fuel consumption during a test on magnetic tape and on paper tape. The fuel canister which is constructed of stainless steel sits on top of the weigh scale and serves as the test fuel container. It is vented to the atmosphere to prevent a build-up of pressure or vacuum during a test cycle. It is connected to the fuel supply and return lines via clear flexible plastic tubes. These serve to isolate the fuel canister from the rest of the system so that only its weight and the weight of the fuel inside are sensed by the scale. In addition, the clear lines provide a visual means of ensuring that all vapour and air bubbles are eliminated from the fuel lines during the purging cycle.

A positive displacement electric fuel pump is used to supply fuel under pressure through the supply line to the vehicle. The supply pump output pressure was controlled by means of an adjacent pressure regulator with pump supply pressure monitored by a pressure gauge. Since reverse flow is not possible through the electric supply pump, a solenoid controlled bypass valve was installed in a loop circuit around the electric fuel pump.

This permitted fuel supply line pressure to be bled-off to zero pressure when the electric fuel pump and test vehicle engine was not operating during the Hot Soak portion of the test cycle. This system was judged to best match the operating characteristics of the system.

Since it was desirable that the temperature of the test fuel delivered to the vehicle carburetor be as close to the test temperature as possible to simulate actual starting conditions, a heat exchanger was installed in the fuel supply line in the cold room. A cooling fan was used to aid in temperature stabilization of the fuel when necessary.

The fuel supply system at the vehicle was designed and built to provide as closely as possible the same operating characteristics as the original fuel system and to eliminate areas where air and vapours could become trapped.

Tests were performed to verify that the pressure of the fuel supplied to the carburetor by the OEM mechanical fuel pump under different operating conditions such as idle, wide open throttle, and steady cruise met design specifications. The pressure remained within specifications (24.1 KP_a - 27.6 KP_a/ 3.5 psi - 4 psi) for all operating modes. The pressure regulator at the vehicle was set to a nominal pressure of 26.2 KP_a (3.8 psi) with the vehicle running. Fuel pressure at the carburetor was monitored by means of a pressure transducer and electronic readout. An assortment of on/off valves and quick connects were installed on the vehicle as illustrated in Figure 1 in order to provide the necessary operating modes for the fuel supply system, including operation of the OEM fuel system for track testing.

2.2.2 Modes of Operation

The gravimetric fuel consumption system was used in three modes of operation during chassis dynamometer testing. A brief description of these operating modes follows.

2.2.2.1 Purge Mode

In preparation for chassis dynamometer testing, the test vehicle is rolled onto the dyno and connected to the gravimetric fuel system supply line and purge line using the appropriate quick connects. Prior to testing all air or fuel vapour trapped in the fuel system or introduced into the fuel system during vehicle hook-up is evacuated by:

- turning on the electric fuel pump;
- closing the solenoid bypass valve;
- closing the vehicle OEM mechanical fuel pump shut-off valve;
- closing the carburetor shut-off valve; and,
- opening the purge valve.

Fuel is then recirculated from the fuel canister through the entire gravimetric fuel supply system and returned to the fuel canister via the purge line. Any air or vapours in the fuel system are purged through the fuel canister vent valve.

2.2.2.2 Test Mode

During testing the fuel system purge circuit is disconnected at the test vehicle using the appropriate quick connect. The fuel supply line from the fuel canister is left connected. A constant fuel pressure is supplied to the test vehicle carburetor through the fuel system supply line from the fuel canister by:

- turning on the electric fuel pump;
- closing the solenoid bypass valve;
- closing the vehicle OEM mechanical fuel pump shut-off valve;
- opening the carburetor shut-off valve; and,
- closing the purge valve.

2.2.2.3 Hot Soak Mode

The fuel system of unmodified Omni/Horizon vehicles incorporates a return line to the fuel tank from the engine driven mechanical fuel pump, as illustrated in Figure 1. As a result, when the vehicle engine is not running all pressure in the carburetor supply line is bled-off through the mechanical fuel pump return line. With the gravimetric fuel system it was important to simulate this type of operation during the hot soak portion of the city driving cycle between Bags 2 and 3 to prevent flooding of the carburetor and/or undue loading of the evaporative emissions cannister. This was accomplished by turning off the electric fuel pump and opening the electric fuel pump bypass solenoid valve during the ten minute hot soak. All pressure in the carburetor supply line then bled-off into the gravimetric fuel canister. Upon starting the Bag 3 portion of the test cycle, the solenoid bypass valve was closed and the electric fuel pump was turned on as the test vehicle engine was started.

2.3 Test Fuel Specifications

The fuel used for the testing program was regular leaded gasoline. Samples of the test fuel were submitted for analysis to Quality Engineering Test Establishment by Transport Canada. The analysed specifications, summarized in Table 2, are shown in detail in Reference 1. The fuel for the test program came from a common batch, 13,620 litres (3,000 gallons), stored in a 22,700 litre (5,000 gallon) underground tank and was used for all testing (both track and dynamometer) at all temperatures.

2.4 Test Facilities

The testing was carried out at the Transport Canada Motor Vehicle Test Centre at Blainville, Quebec. The Centre is situated north of Montreal on 1,250 acres of Federal land. The following Test Centre facilities were used in this project.

2.4.1 Large Environmental Chamber

The large environmental test chamber has a floor area of 93 square meters (1,000 sq. ft.) and height of 6.4 meters

(21 ft.). Its refrigeration system is capable of controlling the operating temperature to within 1.5 C° (2.7 F°) between the range of -40°C to 0°C (-40°F to 32°F).

2.4.2 Clayton Model CTE 50 Dynamometer

The unit is a standard emission water brake dynamometer consisting of four steel rolls with pneumatic roll air brakes and lift. It is mounted flush with the floor inside the environmental chamber. The system coolant consists of a water/glycol mixture to withstand the sub-zero temperatures. Roll bearings have been replaced with sealed bearings with low temperature grease. A power absorption unit connected directly to one of the rolls along with inertia weights permits the simulation of loadings from 0-50 HP and 455 kg (1,000 lb.) to 4,025 kg (8,875 lb.) respectively.

2.4.3 Low Speed Track

The 7.3 m (24 ft.) wide by 6.9 km (4.3 mile) long low speed track was used for driveability testing of the test vehicles in their reference and modified configurations. In addition, test vehicle coast downs for the determination of road load horsepower for the engine block heat conservation vehicle were conducted on the low speed track.

2.4.4 Laboratory

The 4,700 square meter (50,590 sq. ft.) laboratory includes a machine shop for general repairs or fabrication of new specialized equipment and a vehicle preparation area including a vehicle hoist and vehicle storage area.

2.4.5 Service Station

This facility is adjacent to the low speed track and is equipped as a commercial two bay service station.
It was used for the scheduled weekly maintenance checks on each vehicle.

2.5 Test Equipment/Instrumentation

2.5.1 Digital Data

Pertinent vehicle engine and test cell temperatures and operating parameters were monitored digitally during vehicle soak and testing, typically at thirty second intervals. Table 3 lists details of the thermocouples used in the program and their locations.

2.5.2 Analog Data

In addition to the temperatures listed in Table 3 other test vehicle engine parameters were monitored on a continuing basis during dynamometer testing. A list of these parameters and associated sensors and instrumentation is given in Table 4. All test vehicles were equipped with this instrumentation.

2.5.3 Miscellaneous Equipment/Instrumentation

Table 5 lists the remaining equipment and instrumentation used in the project. These were used for testing, maintenance, calibration, and data reduction. Photographs of the general instrumentation layouts are given in Figures 4 to 7.

3.0 TEST PROCEDURES

3.1 Driveability Test Procedure

Vehicle driveability testing was performed on the low speed test track at the Transport Canada Motor Vehicle Test Centre using the Chrysler SID (Start, Idle, Drive) Vehicle Driveability Rating Procedure (see Appendix 1).

Prior to testing, vehicles were first preconditioned for 16 to 32 km at 80 km/hr (10 to 20 miles at 50 mph) and then soaked for 14 to 24 hours.

A summary of the Chrysler Driveability Rating Procedure used is given below.

3.1.1 Cold Start and Warm-up

The vehicle was started according to manufacturer's recommendations. The start rating was based on the time required to start the engine and the number of die-outs that occurred during starting. The vehicle was then driven on the test track and rated for idle quality and driveability as it warmed up.

The driving cycle consisted of a series of light, medium, and heavy throttle accelerations with stops every 0.16 or 0.32 km (0.1 or 0.2 miles). A 60% throttle opening was used for a heavy acceleration; 40% and 25% throttle openings for medium and light accelerations, respectively. The overall cycle length was 4.8 km (3.0 miles).

3.1.2 Vehicle Fully Warmed Up

When the vehicle was fully warmed up, as indicated by stable coolant temperature, the next series of tests was performed. The vehicle was rated for idle, driveability, and performance. The driveability consisted of 50 and 65 kmph (30 and 40 mph) steady state cruises with accelerations from 50 to 65 kmph (30 to 40 mph) and 65 to 90 kmph (40 to 55 mph). The performance evaluation consisted of wide open throttle accelerations from 0 to 65 kmph (0 to 40 mph), 50 to 90 kmph (30 to 55 mph), and 80 to 100 kmph (50 to 60 mph).

3.1.3 Hot Start

The vehicle was shut off and allowed to soak for ten minutes. A hot start and driveability tests were then performed as in paragraph 3.1.1.

3.1.4 Partial Cool-down

The vehicle was shut off and allowed to soak for sixty minutes. Start and driveability tests were then repeated as in paragraph 3.1.1.

3.1.5 Driveability Rating

In each case, starting ease, idle quality, driveability, and performance were noted on a scale of 1 to 9 (9 = best). Numerical ratings for each of the above categories are precisely defined in Appendix 1, and the driveability ratings should therefore only be interpreted by referring to the rating procedure in Appendix 1. For example, a 7* start rating at an ambient temperature of $0^{o}C(32^{o}F)$ indicates a 1.0 second or less start time with one engine die-out.

3.2 Scheduled Vehicle Maintenance

To ensure that the test vehicles operated at recommended specifications vehicle maintenance was performed for each test vehicle, generally on a weekly basis. All maintenance items included in the "Test Vehicle Maintenance Record" of Appendix 2 were covered during test vehicle servicing. Factory recommended service procedures as outlined in the "Chassis Body Service Manual" (Reference 2) were followed. The following is a summary of the scheduled vehicle maintenance procedure.

3.2.1 Service Operations

The engine oil, oil filter, and spark plugs were replaced with standard Chrysler parts.

3.2.2 Specifications and Adjustments

The engine was started and allowed to warm up to normal operating temperature. Engine parameters including ignition timing, curb idle speed, enriched idle speed, fast idle speed, throttle stop speed, vacuum kick setting, choke index, and fast idle cam index were then checked and adjusted if necessary to ensure that they were at the proper configuration specifications.

3.2.3 Operational and Visual Checks

The test vehicles were checked to ensure that they were operating normally. Corrective measures were taken as necessary. A listing of key visual check items is included in the "Test Vehicle Maintenance Record" of Appendix 2.

3.3 Dynamometer Test Procedures

3.3.1 Dynamometer Calibration

The dynamometer was calibrated on a regular basis to promote test to test repeatability and ensure the good quality of dynamometer test results. The procedure consisted of an electrical road load power control (RLPC) calibration, a mechanical calibration, and a torque/horsepower versus speed verification.

3.3.1.1 Electrical Road Load Power Control Calibration

The electrical (RLPC) calibration comprised a complete factory calibration procedure as outlined in Appendix 3 or a basic calibration procedure as outlined in Appendix 4. The former consisted of a systematic check of the entire RLPC unit and was only necessary if the basic calibration procedure proved inadequate or a major system component such as a printed circuit board was changed. The basic calibration procedure, which is a condensed version of the factory procedure, was generally performed on a weekly basis at ambient temperatures between 20°C and 30°C (68°F and 86°F). It consisted of the following system checks.

3.3.1.1.1 Load Glycol Pressure Regulator

The glycol regulator was checked for a reading of 1.7 bars (25 psig) with the load valve open.

3.3.1.1.2 P.A.U. Bleed Port Air Pressure Regulator

The air pressure regulator was checked for a reading of .83 bars (12 psig).

3.3.1.1.3 Roll Speed Calibration

A calibration of the tachometer generator was done at rear and front roll speeds of 1,800 rpm.

3.3.1.1.4 Torque Cell Calibration

Torque cell output was verified at both zero and full scale with a simulated speed of 80 kmph (50 mph).

3.3.1.1.5 Horsepower Scaling Verification

The horsepower scaling was adjusted to an accuracy of ±.1 hp at five different torque cell output values and a simulated speed of 80 kmph (50 mph).

3.3.1.1.6 Low Rate Deadband Adjustment

The low rate deadband was adjusted to ±0.2 hp and centered around three operating points (3.0 hp, 30.0 hp, and 39.0 hp).

3.3.1.1.7 High Rate Deadband Adjustment

The high rate deadband was adjusted to ±1.5 hp and centered around 39.0 hp.

3.3.1.1.8 Driver Cut Off Adjustment

The driver cut off was adjusted in the "RUN" mode at 0.00 hp.

3.3.1.2 Mechanical Calibration

The mechanical calibration was performed to determine the accumulated frictional losses in the dynamometer/flywheel system, thus permitting the determination of the actual road load power seen by the test vehicle. The procedure (see Appendix 5) involved measuring the time for the dynamometer drive (front) roll to coast down from 90 kmph to 72 kmph (55 mph to 45 mph) at indicated power (HP_I) settings of 5.0, 6.0, and 7.0 hp. The actual road load power (HP_d) present at the dynamometer front roll is calculated from the kinetic energy dissipated by the dynamometer rotating components as follows:

$$HP_d = (\tfrac{1}{2})(W^*/32.2)\left(\frac{V_1^2 - V_2^2}{550\ \Delta t_{avg}}\right) \qquad (1)$$

where V_1, V_2 = vehicle speed (ft/sec)

W = inertia weight (lbs.)

t = time (sec.)

The frictional losses (HP_f) were then calculated from,

$$HP_f = HP_d - HP_I \qquad (2)$$

---

* Not including rear roll inertia weight (lbs.)

Dynamometer frictional losses were calculated using this procedure generally on a weekly basis at ambient temperatures between 20°C and 30°C (68°F and 86°F) after the electrical RLPC calibration had been performed.

3.3.1.3 Torque/Horsepower Versus Speed Verification

As a final check on the electrical/mechanical operation of the system, torque versus front roll speed and horsepower versus front roll speed curves were plotted and compared with the theoretical curves. These plots (see Appendix 6 for procedure and Figure 8 for theoretical curves) were useful in verifying the following:

i) load cell calibration;
ii) horsepower scaling calibration;
iii) deadband adjustment;
iv) exponent verification;
v) front roll speed calibration;
vi) thumbwheel calibration; and,
vii) operation of load/unload valves.

This procedure was initiated toward the end of the program and was performed following the electrical RLPC calibration, generally on a weekly basis.

The above procedure was also used to verify the operation of the mechanical portion of the dynamometer. With the dynamometer operation switched to "Pendant Control" and the dynamometer manually loaded to 11.0 hp at 80 kmph (50 mph) the two curves were plotted again under purely mechanical control.

3.3.2 Dynamometer Mechanical Warm-up

Measures were taken to ensure that the dynamometer was fully warmed up prior to testing. The dynamometer was warmed up if it had not been operated within the previous:

- two hours at ambient temperatures of 20°C to 30°C (68°F to 86°F);
- one half hour at ambient temperatures below 20°C (68°F).

This consisted of driving a vehicle on the dynamometer at 80 kmph (50 mph) for thirty minutes, at the test road load power and inertia weight settings. A slave vehicle was left in the cold chamber at all times to perform dynamommeter warm-up functions to avoid having to use test vehicles for this purpose.

3.3.3 Instrumentation Warm-up and Preparation

Customarily the power to the dynamometer electronics and remaining instrumentation was not turned off except over weekends. In such cases the electronic RLPC unit was allowed thirty minutes to stabilize when first turned on while the data acquisition equipment (see Section 2.5 for a list of the equipment) was allowed a minimum of one hour to warm-up prior to any testing or calibration.

3.3.4 Fuel Consumption Test Methods

Fuel consumption tests were conducted on a chasis dynamometer in the low temperature test chamber. City and highway fuel consumption tests were run in accordance with applicable Transport Canada Test Methods (References 3 and 4). It should be noted that the Transport Canada driving cycles and test methods, as used in this project, are equivalent to current U.S. EPA requirements with the exception that fuel consumption was determined gravimetrically, rather than through carbon balance techniques. In addition, for this program, tests were run with vehicle hoods closed. City and highway driving schedules are detailed in Appendices 7 and 8.

3.3.5 Laboratory Procedures

Laboratory test procedures were developed to meet the exacting requirements of the referenced Transport Canada Test Methods. These procedures were designed in a step-by-step check off format to minimize the chances of procedural errors and ensure consistency in testing methodology. The laboratory test procedures are detailed in Appendix 9. A complete fuel consumption test consisted of the following elements:

- vehicle preconditioning;
- city cycle fuel consumption test;
- highway cycle fuel consumption test;
- post highway cycle preconditioning.

3.3.5.1 Vehicle Preconditioning

For vehicle preconditioning the test vehicle was driven through the city, highway, and post-highway preconditioning cycles as detailed in Sections 3.3.5.2 to 3.3.5.4. Generally, the vehicle was not soaked at the ambient test temperature prior to preconditioning although the cold room temperature was within ±2 C° (3.6 F°) of the test temperature at the start of preconditioning. Fuel consumption data obtained from these cycles was not included with the actual test data. Vehicle preconditioning was performed under the following circumstances:

i) as a first run on a vehicle after modification to a new configuration;

ii) as a first run on a vehicle after a change in the test temperature; and,

iii) between successive fuel consumption tests of similar configuration when the soak period exceeded 24 hours.

3.3.5.2 City Cycle Fuel Consumption Test

In preparation for the city cycle fuel consumption test, the test vehicle was soaked in the cold room at the test temperature for 14 to 24 hours. Where possible soak times were kept constant from test to test.

City cycle tests were run from a cold start with the engine compartment hood closed at all times.

Gravimetric fuel consumption measurements were taken at thirty second intervals throughout the test and at the start and end of Bags 1, 2, and 3.

3.3.5.3 Highway Cycle Fuel Consumption Test

Immediately upon completion of the city test, the highway fuel consumption test was run. The test vehicle engine was not turned off between the two tests and the engine compartment hood remained closed throughout the entire highway test. Gravimetric fuel consumption measurements were taken at thirty second intervals and at the start and end point of the cycle.

3.3.5.4 Post-Highway Cycle Preconditioning

The test vehicle was driven through a preconditioning cycle immediately following the highway cycle. This consisted of steady state driving at 80 kmph (50 mph) for twenty minutes with the dynamometer set at the test condition for road load power and inertia weight. The purpose of this cycle was twofold:

- i) to clean the spark plugs; and,
- ii) to purge any gasoline vapours from the crankcase oil thus ensuring that its frictional properties remained constant.

By this means, it was not necessary to change the oil and spark plugs after every test.

3.3.5.5 Laboratory Test Procedure Summary

Previous sections have described in some detail the various elements involved in a complete fuel consumption test. A typical sequence of events was as follows:

(a) warm up dynamometer (if applicable) using slave vehicle, as described in Section 3.3.2;

(b) install and tie down vehicle on the dynamometer (without starting the vehicle engine);

(c) purge fuel system as detailed in Section 2.2.2.1

(d) hook up transducers to test vehicle and ensure proper operation (see Section 2.5 for a description of the various transducers);

(e) set the inertia weight and road load horsepower to the test requirement;

(f) enable the data acquisition system and ensure proper operation of all the instrumentation (see Section 2.5 for a description of the instrumentation);

(g) proceed with vehicle preconditioning if required, as described in Section 3.3.5.1, or proceed with city fuel consumption test as described in Section 3.3.5.2;

(h) proceed with highway fuel consumption fuel test as described in Section 3.3.5.3;

(i) proceed with post-highway preconditioning run as described in Section 3.3.5.4; and,

(j) calculate the city and highway fuel consumption and assess the validity of the run as detailed in Section 3.3.6.

3.3.6 Dynamometer Test Run Validity Criteria

A number of items which could affect fuel consumption and test-to-test repeatability were considered in the assessment of the validity and subsequent acceptance or rejection of a test run. A copy of the test quality control sheet summarizing these items is contained in Appendix 10. These criteria were used as a guide with judgment being exercised in the final decision. A discussion of the validity criteria follows.

3.3.6.1 Driver's Aid Trace

A test run was generally considered void if the required tolerances of paragraph 8.6.2 of the Vehicle Emissions Test Method (Reference 3) were not met during the driving cycle. The required tolerance had an upper limit 3.2 kmph (2 mph) higher than the highest point on the trace within one second of the given time and a lower limit of 3.2 kmph (2 mph) lower than the lowest point on the trace within one second of the given time.

3.3.6.2 Vehicle Operating Parameters

Four vehicle operating parameters were measured and recorded between the city and highway test cycles. These items and their normal operating ranges were as follows:

With Vehicle in Netural:

Hot Curb Idle:	850 - 1,000 rpm
Basic Timing:	13° - 17°(for all runs except 5.3) 20° - 24°(for run 5.3)
Manifold Vacuum:	60.7 KPa (18" Hg nominal)
Carburetor Inlet Temperature:	23° - 43°C (74°F - 110°F)

If any of the measurements deviated significantly from the normal range, then the test was considered void.

3.3.6.3 Temperature Control

For test acceptance the average test cell and fuel temperatures had to be within ±5 C° (9 F°) of the desired test temperature.

3.3.6.4 Dynamometer Roll Revolutions

The accumulated number of roll revolutions during each of the three bags in the city cycle and over the highway cycle had a stringent tolerance of ±3% of a nominal value. If outside this range, the run was considered void.

3.3.6.5 Average Quick Coast-down Times

Three quick coast-down tests were conducted on the chassis dynamometer with the test vehicle in a fully warmed up condition after the highway cycle test. The road load horsepower and inertia weight remained at the test settings.

The quick coast downs consisted of timed decelerations of the test vehicle from 88 kmph to 72 kmph (55 mph to 45 mph) with the vehicle transmission in neutral. Variation in coast down times beyond the recommended tolerance indicated changes in dynamometer loading and/or test vehicle rolling friction.

3.3.6.6 Overall Elapsed Test Time Data

Tolerances were put on the total time to complete a city and highway test and on the hot soak portion of the city test. Exceeding the tolerance on the former indicated that an inconsistency had occurred during the driving cycle.

3.3.6.7 Odometer Reading

Odometer readings were taken before and after a test as a course indicator of test distance. A correlation was expected with the roll revolution counter.

3.3.7 Block Heater Warmup and Vehicle Cooldown Temperature Monitoring Test Procedure

Various engine and related temperatures were monitored and recorded during the block heater warmup and natural vehicle cooldown tests on the Block Heat Conservation Vehicle at -20°C (-4.°F) These included the following:

- a) Transmission Oil
- b) Left Hood
- c) Stove Output
- d) Carb Air Inlet
- e) Crankcase Oil
- f) Frost Plug
- g) Thermostat

Cool-down tests were performed with a warmed up test vehicle. The referenced temperatures were monitored for a 10-14 hour cool-down period, after which time the block heater was plugged in. Temperatures were then again recorded through a 9-14 hour warm-up period. These tests were repeated twice for the base and modified configurations of the Engine Block Heat Conservation Vehicle. Data for all tests was recorded every 10 minutes.

3.4 Fuel Consumption Calculation Procedure

The following is the relationship used for the calculation of fuel consumption for both city and highway tests.

$$\underset{(\ell/100\ \text{km})}{\text{Fuel Consumption}} = \frac{\text{FUEL CONSUMED (gm)} \times 144.686^{*}}{\text{ACCUM ROLL REVS} \times \text{Fuel Specific Gravity}} \qquad \text{①}$$

where Fuel Specific Gravity = .7003 (see Section 2.3)

* 144.686 = unit conversion constant

For the city cycle:

Fuel Consumed (gm):

$$= \left[(0.43 \times (\text{BAG } 1)) + (\text{BAG } 2) + (0.57 \times (\text{BAG } 3)) \right]$$

and Accumulated Roll Revolutions:

$$= \left[(0.43 \times (\text{BAG } 1)) + (\text{BAG } 2) + (0.57 \times (\text{BAG } 3)) \right]$$

For the highway cycle, equation ① is used directly.

The combined fuel consumption rating is calculated as follows:

$$\text{Combined Rating} = .55 \times (\text{City Consumption}) + .45 \times (\text{Highway Rating})$$

3.5 Calculation of Repeatability

The number of tests performed for each designated vehicle configuration at each test temperature varied between a maximum of four tests and a minimum of two tests as a function of test repeatability based on the coefficient of variation of fuel consumption results. Coefficients of variation were calculated independently for the city and highway tests. If both the coefficients of variation for the city and highway cycles of all valid runs were $\leq 1.5\%$, no further runs were done with this configuration and temperature. The equations used for calculating the standard deviation (S) and coefficient of variation (V) were:

$$S = \sqrt{\sum_{i=1}^{n} \frac{(\bar{X} - X_i)^2}{n - 1}}$$

$$V = \frac{S}{X}$$

where n = number of valid tests

$\bar{X}$ = mean fuel consumption of all valid runs

X_i = individual test fuel consumption values

Thus if $V \leq 1.5\%$ then no further tests were done. All calculations for repeatability were recorded as indicated in Appendix 10.

3.6 Data Acquisition

Data acquisition was provided by a Digitec 3000 Datalogger system and Watanabe 6-channel analog recorder. The programmable Digitec provided the multiplexing of the signals from the fuel canister weigh scale, revolution counter, digital

humidity analyser, and all thermocouples.
Hard copy output from the Digitec was on paper tape. In addition, a Memodyne 400 Transport system was interfaced with the Digitec to provide permanent storage of all the data on cassette tape. The Watanabe recorder provided a continuous analog record throughout the fuel consumption test of ignition timing, engine speed, choke position, manifold vacuum, battery voltage, and tailpipe caron monoxide level.

3.6.1 Data Reduction and Analysis - Calcomp Plots

Data from selected test runs for each vehicle configuration and ambient test temperature was reduced into graphical form using a Calcomp Model 81 plotter interfaced with a PDP-11 microcomputer. These plots, which traced temperature and fuel consumption histories throughout the test, can be broken down into the following three categories:

i) Temperature and Fuel Consumption Traces;
ii) Parameter Comparison Traces; and
iii) Vehicle Cool-down and Block Heater warm-up Temperature Traces.

3.6.1.1 Temperature and Fuel Consumption Traces

Temperature and fuel consumption traces were made for selected runs of each vehicle in the testing program. Traces were made for both city and highway cycles with the city cycle being plotted on three separate graphs for better resolution. Tables 6 to 8 give a summary of the parameters and test runs that were plotted for each vehicle. For this series of traces, all indicated test parameters were plotted for a particular test run on one graph.

3.6.1.2 Parameter Comparison Traces

These graphs consisted of the same temperature and fuel consumption data used in the graphs described in Section 3.6.1.1, but with the data presented in a different manner. For these traces, an individual parameter was chosen and plotted for all the dynamometer runs on a particular vehicle. In this way the effect of test temperature and vehicle modifications on that parameter could be more easily studied.

3.6.1.3 Cooldown and Warmup Traces

Temperature versus time data from the cooldown and warmup tests were plotted separately using both a normal and expanded temperature scale. Table 9 summarizes the data plotted from these tests.

3.6.2 Data Reduction and Analysis - Watanabe Analog Traces

As stated earlier, the Watanabe recorder was used to provide a continuous analog record of six engine-related parameters throughout the fuel consumption tests. Output from the recorder was continually monitored throughout the test to verify that various tune-up specifications were within tolerance. This helped to ensure consistency between runs throughout the program. Table 10 summarizes the recorder outputs and scales used for all tests. Figure 9 shows the scaling on a blank portion of strip chart recorder paper. As indicated, the scales for channels 5 and 6 were adjusted partway through the program to make the output easier to read. The runs which conform to the old scale setup are all tests on vehicles 4 and 5 in their base configuration (4.1 and 5.1 series) and all tests on vehicle 2 except 2.2.3-2, 2.2.3-3, 2.2.4-2, 2.2.4-3 and the 2.3 series.

For resolution purposes the recorder was run at two different chart speeds during fuel consumption tests. For the portion covering the initial cold start of the vehicle until the driving cycle commenced the chart was run at 600 mm/min. For all other portions of the test the chart speed was 75 mm/min.

Figure 10 contains a black and white copy of a typical start up trace. With respect to the figure, the following procedure outlines the steps taken in deriving some pertinent test data from the chart:

a) Time to First Fire - See Figure 10

b) Start Time - (Key Release Time) - See Figure 10

c) Cranking Voltage

  i) draw a box around the first four cycles of cranking voltage curves;

  ii) put an "X" through the box;

  iii) cranking voltage is the voltage at the center of the "X"

d) Cranking Speed (for 600 mm/min chart speed only)

  i) measure length of box drawn in c) step i) above; length in centimeters is equivalent to time in seconds for two revolutions of the engine

  ii) engine speed

$$= \frac{2 \text{ rev}}{(X) \text{ sec}} \times 60 \frac{\text{sec}}{\text{min}} = \frac{120}{(X)} \text{ rpm}$$

  For the example shown on Figure 10, the cranking speed would be:

$$\frac{120}{1.0} = 120 \text{ rpm}$$

3.7 Track Coast-down Procedures

Among the modifications to the Block Heat Conservation test vehicle were an under-engine pan and a radiator-mounted winterfront. It was expected that these modifications would result in improvements in aerodynamic drag and subsequent reductions in road load horsepower at 80 kmph (50 mph). In this regard, track coast-downs were conducted by Transport Canada personnel on the low speed track using the procedures and instrumentation detailed in Appendix 11. The Transport Canada procedures are consistent with current EPA requirements for test track determination of road load horsepower. Coast-down tests were run on a:

- base (unmodified) vehicle;
- base vehicle with under-engine pan and winterfront (shutters open) installed; this simulated operation at 25°C (77°F);
- base vehicle with under-engine pan and winterfront (shutters closed) installed; this simulated operation at -20°C (-4°F).

Since track coast-downs were conducted at very cold ambient conditions, -6°C (21.2°F), no attempt was made to quantify absolute road load horsepowers but merely to establish the relative difference in the three test vehicle coast-down configurations investigated. Such differences could then be applied to the previously established road load horsepower for a base vehicle tested at an EPA acceptable ambient temperature.

3.8 Hardware Configurations Tested

The hardware details and operational descriptions of all of the test configurations, including the base vehicle, are given in this section. The test number interpretation scheme is given in Table 11. Tables 12 to 14 relate the test numbers to the hardware configurations and the type of tests performed for each of the vehicles.

3.8.1 Base Vehicle Configuration

Vehicles were tested in their base configuration in order to establish a baseline for configuration comparisons. The test vehicles were 1980 Dodge Omni/Plymouth Horizon models, equipped with a 1979 carburetor, Electronic Spark Advance Unit (ESA), distributor and exhaust gas recirculation valve. All vehicles had between 9000 and 14000 km (5580 and 8680 miles) accumulated before the start of the program. It should be noted that in the case of the E.F.E. vehicle, base configuration testing was done with the EFE heated grid installed, but not operational. This was done to eliminate any fuel/air distribution effects caused by the heater grid itself between the base and modified vehicle. Table 15 lists the pertinent base vehicle specifications.

3.8.2 Early Fuel Evaporation (EFE) Configuration

With this configuration, several changes were made to the base engine of test vehicle #2 to improve fuel vaporization during engine warmup. These changes included:

- electrical hook-up of the heated grid between the carburetor base and intake manifold;
- installation of an exhaust manifold incorporating pin-fins for improved stove performance;
- installation of a redesigned "full wrap" heat stove over the pin-finned exhaust manifold.

The improved warm-up characteristics of the intake charge were expected to enhance driveability and make fuel consumption improvements possible as a result of leaner choke calibrations. More specific details of the modifications involved in the EFE configuration follow, along with an operational description of the system.

3.8.2.1 Pin-Fin Exhaust Manifold

An exhaust manifold incorporating pin-fins, as illustrated in Figure 11, was installed on the test vehicle. The purpose of the fins was to improve stove performance by improving heat transfer from the exhaust manifold surface to the incoming air.

3.8.2.2 Full-Wrap Heat Stove

In the production engine, the heat stove covers approximately one-quarter (¼) of the exhaust manifold. This would increase the capability to heat intake air during periods of stove operation. For the EFE configuration, the stove was redesigned to provide almost total coverage of the exhaust manifold, as illustrated in Figure 12.

3.8.2.3 Heated Grid

The heated grid, constructed from a barium titanate ceramic material formed into a honeycomb structure, (Figure 13) was installed in the intake manifold beneath the carburetor primary barrel. The electrically heated grid is self regulating in nature. Initially, when cold, the grid draws approximately 15 amps. When fully warmed up to approximately 160°C (320°F), with no air flow through the grid structure, it draws approximately 1 to 2 amps. When the engine coolant temperature reaches 65.6°C (150°F), electric current supply to the heated grid is switched off. The EFE circuit, illustrated in Figure 14, was used for all testing.

The primary purpose of this grid is to improve fuel vaporization. It should be noted that the heated grid was changed on February 2, 1981 to a new design offering greater structural integrity with no change in operational characteristics.

3.8.2.4 Choke Heater

The production choke heater assembly was replaced with an experimental "constant-on" unit incorporating a 140°C (284°F), 0.850 cm (.335 in.) diameter "pill".

The experimental component does not have a thermostatically controlled second stage as the production unit does. Instead, full heat (electrically generated) is applied to the choke bi-metallic coil at all times regardless of vehicle or ambient temperatures. This provides faster choke-off times at colder temperatures.

3.8.2.5 Choke Bi-Metallic Coil

The production bi-metallic choke coil was replaced with an experimental unit designed to give shorter choke-on times. Specifications for the two coils are shown in Table 16. Among the features of the experimental coil are less torque and greater activity.

3.8.2.6 Choke Index

Choke indexing was changed from 87½° for the production unit to 82½° for the EFE configuration. This reduces initial choke coil pretension and promotes faster choke-off times.

3.8.2.7 Vacuum Kick

The choke vacuum kick adjustment was changed from a production setting of 1.016 mm (0.040") to 2.413 mm (0.095"). This would result in leaner air fuel ratios during the early part of the choke cycle.

3.8.2.8 Vacuum Delay Valve

A "10 second" vacuum delay valve was installed in series with the choke vacuum kick actuator. This device was installed to prevent engine die-outs during cold starts by delaying choke vacuum kick operation until the EFE heated grid had reached operating temperature.

3.8.2.9 Summary of EFE System Operation

The EFE system consisted of a number of passive and active components designed to work in harmony to improve driveability and fuel consumption by improving the cold engine warm-up characteristics and fuel vaporization and thereby permitting faster choke-off times. System operation can be divided into three broad catagories, including intake air management, fuel vaporization, and choke operation.

During engine warmup, intake air was heated to a higher temperature at a greater rate by means of the pin-finned exhaust manifold and full-wrap stove assembly. Fuel vaporization during warm-up was enhanced by means of the temperature self-regulating heated grid, as well as the higher temperature intake air resulting from the improved stove. Heated grid operation was geared to engine coolant temperature with respect to supply current switch off. To reduce choke-on time, the choke was recalibrated as described earlier.

3.8.3 Engine Block Heat Conservation Configuration

Modifications associated with the Block Heat Conservation Configuration were made to vehicle #4. This configuration was designed to improve fuel economy by shortening engine warmup time and maintaining heat within the engine block and engine compartment during cold weather operation by:

- reducing air flow through the engine compartment to a minimum,using a radiator mounted winter front and an under-engine pan;
- minimizing heat loss from the engine block using insulation;
- minimizing coolant flow through the radiator when the engine is cold by means of a "no-bleed" thermostat.

An added benefit with this configuration,resulting from the improved air flow over the test vehicle,was a significant reduction in road load horsepower at 80 km/hr (50 mph), as demonstrated during track coastdown testing.

Finally a separate series of tests was done on the base vehicle equipped with a production block heater to investigate the relationship between block heater on-time before a cold start, and vehicle fuel consumption.

Details of the hardware in the Block Heat Conservation Configuration (Figure 15) and operational descriptions of the system follow.

3.8.3.1 Winter Front Assembly

The experimental winter front used in this program was a radiator mounted design incorporating thermostatically controlled shutters. A 65.6°C (150°F) "vernatherm" unit was used to control shutter opening based on lower rad temperature.

A schematic of the winter front plumbing is illustrated in Figure 16.

3.8.3.2. Under-Engine Pan

The under-engine pan, illustrated in Figure 17, was fabricated from alluminum and fastened to the chassis of the test vehicle to enclose the engine compartment between the lower edge of the head lamp mounting closure panel and the rear edge of the front suspension crossmember. The pan was louvered to provide air flow through the engine compartment when the winterfront was open.

3.8.3.3 No-Bleed Thermostat

The engine thermostat was a prototype "no-bleed" design which eliminated the bleed hole used in the production component. The production bleed hole aids in filling the cooling system and permits a nominal flow of 0.23 kg/min. (0.5 lb/min.) of coolant through the radiator during engine warmup. A common thermostat opening temperature of 91°C (195°F) was shared by both production and prototype thermostats.

3.8.3.4 Engine Block Insulation

The complete engine block and valve cover was insulated to a thickness of approximately 12.5 mm ($\frac{1}{2}$"), as illustrated in Figure 18, with insulation (Chrysler Material #CR95) having the thermal properties listed in Table 17.

The insulation was applied in paste form and cured to a solid consistency using engine heat. The outer surface of the insulation was sealed using a ceramic sealant (Chrysler Material #CR124) to improve durability.

3.8.3.5 Block Heater

A production 400 W block heater was used for block heater evaluations.

3.8.3.6 Operational Description of Winter Front System

With reference to Figure 16, a description of the system operation, from the time of a cold start to the fully warmed-up engine condition, follows.

3.8.3.6.1 Operation with Engine Thermostat Temperature Less Than 91°C (195°F)

With the engine running and coolant temperature below 91°C (195°F), there is no coolant flow through the rad and hence, no coolant flow through the vernatherm on the winter front.

During this period all coolant either passes through the heater core in the car and returns to the water pump inlet, or passes through the bypass line to the water pump inlet.

3.8.3.6.2 Operation with Engine Thermostat Temperature Greater Than 91°C (195°F), Lower Rad Temperature Less Than 71°C (160°F)

As the engine coolant temperature rises above 91°C (195°F), the engine thermostat starts to open, allowing coolant to flow through the rad. Until the lower rad temperature rises above 71°C (160°F), all coolant is forced through the vernatherm on the winter front. This 71°C (160°F) lower thermostat is necessary to shorten the response time of the winter front during the critical warmup period. Without this thermostat, it was found that in certain warmup conditions where the engine was kept at idle during the entire warmup, the vernatherm on the winter front lagged dangerously behind the engine in reaching operational temperatures.

3.8.3.6.3 Operation with Engine Thermostat Temperature Greater Than 91°C (195°F), Lower Rad Temperature Greater Than 71°C (160°F)

Once the lower rad temperature reaches 71°C (160°F), the lower thermostat opens allowing the majority of coolant to flow through the large diameter lower rad hose instead of through the vernatherm.

Adequate flow is now maintained through the vernatherm by the coolant pickup which is directed into the coolant flow in the lower rad hose. As the lower rad temperature, and hence, temperature at the vernatherm inlet rises above approximately 71°C (160°F), the winter front starts to open.

3.8.3.6.4 Operation with Fully Warmed-up Engine

With the engine fully warmed-up, the temperature at the vernatherm inlet closely approximates that of the lower rad temperature. Under ideal conditions the shutters act to control air flow through the rad to maintain the lower rad temperature at 63.6°C to 76.7°C (150° to 170°F). During actual use, however, the lower rad temperatures ran slightly above the 65.6°C to 76.7°C (150° to 170°F) operating range of the vernatherm unit. This was probably due to the metal shutter assembly acting as a heat sink for the vernatherm unit, lowering its temperature below that of the engine coolant passing through it.

Finally, when lower rad temperature reaches approximately 93.3°C (200°F), an electric rad fan is energized to assist in cooling.

It is noted that the heater core return hose was piped into the bypass line on both the "base" and "modified" cars instead of into the lower rad hose, as is done in production. This was done to prevent the returning coolant from the heater core from backing up the lower rad hose and prematurely opening both the 71°C (160°F) lower thermostat, and the winter front

3.8.4 High Compression Configuration

Vehicle #5 was used for the high compression testing. The vehicle was tested in both base compression ratio (8.23:1) and high compression ratio (9.52:1) configurations using regular leaded gasoline to evaluate the effects of compression ratio on fuel consumption over the specified range of test temperatures.

Previous testing at Chrysler had indicated that a ratio of approximately 9.5:1 was the highest practical compression ratio for this engine when run on regular leaded gasoline. Table 18 summarizes the nominal and actual base and high compression ratios tested. The engine cylinder head was removed for the actual compression ratio measurement and combusion chamber deposits accummulated during 10,000 km (6200 mi) of use were left in place, while the pistons were clean and free of deposits.

Details of hardware changes, which included a change of pistons and spark control computers (SCC) follow.

3.8.4.1 Piston Change

All baseline tests were conducted with standard production pistons (8.23:1 CR). Upon completion of baseline testing, the test vehicle engine was disassembled to the extent necessary to complete a change to the experimental high compression pistons (9.52:1 CR). While the cylinder head was removed, actual compression ratio determinations were made. During the piston change,cylinder walls were not deglazed, the old piston rings were reused, and combustion chamber deposits were left intact.

3.8.4.2 Spark Control Computer

The standard spark control computer (SCC) was replaced with a programable SCC (Chrysler Model #OEM SCC). Spark schedules used for high compression testing during this program are shown in Table 19 ,along with base SCC specifications. The experimental schedules were developed from engine dynamometer testing performed on an identical engine by the National Research Council of Canada, and from exhaust emissions and fuel economy testing done on a second high compression vehicle at Chrysler's engineering offices. The criteria for spark curve selection was best fuel consumption with comparable emission levels to the base vehicle over the Transport Canada city driving cycle.

3.8.4.3 Kilometrage Accumulation

Following conversion of the engine to high compression configuration and before any testing was done on the vehicle, combustion chamber deposits were stabilized* through a program of rapid kilometrage accumulation, during which 10,000 km ** (6,200 mi) were accumulated in a 10 day period, using 35% city and 65% highway driving.

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* It should be noted that although deposits on the cylinder head were left intact during the piston change, the pistons that were installed were new and therefore free of deposits.

** The metrage chosen was based on data from high metrage accumulation tests done on this engine configuration by a major Canadian oil company.

4.0 RESULTS

This section summarizes the results of the tests performed in the program. Fuel consumption data for the various configurations and test temperatures are detailed in tabular and graphical form. A summary of the various engine temperatures recorded during the fuel consumption tests are presented in graphical form. In addition, temperature traces detailing vehicle cooldown and engine block heater warmup characteristics are included.

4.1 Fuel Consumption

Tables 20-22 detail the average fuel consumption data for each vehicle configuration and ambient temperature tested. The data has units of litres per 100 km (mi/Imperial gal. given in brackets) and represents an average of at least two, and a maximum of four tests (see Section 3.3.6). Fuel consumption histories (grams) over the city and highway cycles for selected runs at each test temperature and configuration are shown graphically in Section 2.0, Volume II. Figure 19 illustrates a typical trace comparing fuel consumed over the cold transient portion of the city cycle for selected runs of the engine block heat conservation vehicle. Tables 6-8 summarize the runs plotted for each vehicle.

4.2 Temperature traces

Temperature traces from the fuel consumption tests, as described in Section 3.6.1.1 and 3.6.1.2, are contained in Sections 3.0 and 4.0 of Volume II. Figures 20 and 21 illustrate the two plotting styles used for the traces. Figure 20 illustrates all the data from one test run (temperature and fuel consumed), all plotted on one graph. The referenced plot shows city cycle (cold stabilized) data from the fourth fuel consumption test on the base configuration of the Early Fuel Evaporation Vehicle at +25°C (77°F). Figure 21 represents a comparison type of plot in which like channels from each run are plotted together on one graph. The referenced trace shows highway cycle stove output temperature data for selected runs. Tables 6-8 summarize the data and runs plotted.

Traces from the block heater warmup and vehicle natural cooldown tests, as described in Section 3.6.1.3, are contained in Section 5.0, Volume II. Figures 22 and 23 illustrate the typical format of these traces using an expanded temperature scale. Identical plots were also done using a normal temperature scale. Table 9 summarizes the data plotted for the base and modified configurations.

4.3 Analog Recorder Traces

Analog recorder traces of various engine related data (items 1-6, Table 4), as described in Section 3.6.2, for each fuel consumption test are stored on file at Transport Canada.

4.4 Driveability Test Results

Driveability test results, as described in Section 3.1, are stored on file at Transport Canada. Table 23 summarizes the SID ratings for all driveability tests conducted.

5.0 DISCUSSION OF RESULTS

5.1 Base Vehicle Test Results

Fuel consumption test results for the base vehicles at +25°C (77°F), 0°C (32°F), and -20°C (-4°F) are shown in Tables 20-22. As expected, fuel consumption of the base vehicles increased significantly at the lower test temperatures. Average fuel consumption increases for the three cars at 0°C (32°F), and -20° (-4°F) compared to +25°C (77°F) fuel consumption were 11.4% and 32.7% respectively for the city cycle, and 2.5% and 6.4% respectively for the highway cycle as illustrated in Table 24.

It should be noted that "real world" fuel consumption penalties at colder temperatures, primarily on the highway, may be somewhat greater than those shown in Table 24. This is because the indicated road load horsepower settings on the dynamometer were not increased at the lower temperature to take into account any increased aerodynamic drag or rolling resistance that would occur in on-road driving. Some or most of the increased rolling resistance would, however, be automatically taken into account by the vehicle itself on the dynamometer. Dynamometer settings to account for ambient temperature effects were not done because the determination of road load horsepower, as a function of ambient temperature using track coastdown techniques was beyond the scope of this project.

5.2 Test Results of Modified Vehicles

5.2.1 Early Fuel Evaporation Configuration

This vehicle was tested in base and two modified configurations. Percent improvements in fuel consumption relative to the base vehicle are shown in Table 25. A discussion of the test results for the two modified configurations follows.

5.2.1.1 Test Series 2.2

With reference to Table 25, the vehicle in this configuration showed fuel consumption improvements of approximately 1% for the city cycle and 2% for the highway cycle at 0°C (32°F), and 4% for the city cycle and 2% for the highway cycle at -20°C (-4°F). A fuel consumption penalty of 4% for the city cycle and 2% for the highway cycle was recorded at +25°C (77°F). In order to better analyze the test results for this vehicle, the city cycle fuel consumption variations were broken down on a bag basis as shown in Table 26.

(See Appendix 12 for the calculation procedure.)

As expected, most of the fuel consumption improvements at 0°C (32°F) and -20°C (-4°F) were obtained in Bag 1 of the city cycle, when the EFE system was operating. Improvements of 12% and 14% respectively over this portion of the city cycle are shown in Table 26.

A significant city cycle fuel consumption penalty, however, was recorded at +25°C (77°F) with the greatest penalty being in Bag 1.

Because of the unexpected increase in fuel consumption at +25°C (77°F) with the EFE system, a series of diagnostic tests was run on the vehicle to determine the cause of the increased fuel consumption. A single test was run with the EFE grid powered by an external power source, but this made no difference to the vehicle fuel consumption (see Table 20). Next, back-to-back runs were made on the vehicle at +25°C (77°F), first with the EFE system fully operational, and then with the EFE grid turned off and the original production choke re-installed. (The full-wrap stove and pin-fin exhaust manifold were left in place for both runs). Resultant city and highway fuel consumption figures were within 0.5% for the two runs. (See Table 20). It was concluded, therefore, that either the baseline fuel consumption on the vehicle had shifted or the prototype stove was adversely affecting the fuel consumption of the vehicle. The latter was judged highly unlikely, since the stove is practically inoperative at a test temperature of +25°C (77°F). The vehicle was returned to Chrysler for analysis. After corrective repairs were made to the vehicle, including the installation of a new spark control computer, it was returned to Transport Canada where it was retested (Test Series 2.3) with the same EFE modifications.

5.2.1.2 Test Series 2.3

Referring to Tables 20 and 25, the EFE car in the re-test had only slightly different results from Test Series 2.2. Fuel consumption for the city and highway cycle was 4% and 1% higher respectively at +25°C (77°F) compared to the base car. At 0°C (32°F) the vehicle essentially broke even with a 1% city fuel consumption gain and 1% loss in highway fuel consumption. At -20°C (-4°F) the vehicle showed city and highway gains of 6% and 1% respectively.

At +25°C (77°F), fuel consumption penalties of approximately 6% for bag 1, 5% for bag 2, and 2% for bag 3 were evident (Table 26). Since the fuel consumption penalty occurs in all 3 bags, even though the EFE system was only operating during bag 1 at this temperature, it is unlikely that the EFE system was the cause of the problem. A portion of the fuel consumption penalty may be due to the fact that the average test temperature was approximately 4-5°C higher for the base vehicle tests than for the tests with EFE. The rest of the penalty could be attributed to a possible shift in the vehicle baseline.

At 0°C (32°F) EFE modifications served to reduce the fuel consumption by approximately 13% over bag 1, while increases of 4% and 3% were evident in bags 2 and 3 respectively. This fuel consumption increase in bags 2 and 3 was probably due to a shift in the vehicle baseline as discussed earlier, since the EFE system was not in operation during this portion of the cycle. At -20°C (-4°F) a decrease of approximately 18% in fuel consumption was evident over bag 1 of the cycle, with a negligible effect over the remainder of the cycle. An overall improvement of approximately 6% was registered over the entire city cycle at -20°C (-4°F).

5.2.1.3 Comparison of Choke - on Times

A comparison of choke-on times, shown in Table 27, indicates the extent to which the "constant-on" choke heater element and experimental coil assembly reduced choke-on times at the colder test temperatures. At 0°C (32°F) choke-on times were reduced by approximately 50%, while at -20°C (-4°F), choke on times were reduced by about 47%. Due to instrumentation problems, comparison data was not available for some of the runs as indicated in Table 27.

The significantly reduced choke-on times,as well as the improved fuel vaporization made possible with the EFE system, most likely account for the fuel consumption improvements in bag 1 at test temperatures of 0°C (32°F) and -20°C (-4°F).

5.2.1.4 Comparison of Start Time

A comparison of the data shown in Table 28 indicates that there is no apparent reduction in start times with EFE at these temperatures if the EFE system is energized when the ignition switch is turned on, as was done in these tests. Any future work done on this package should include runs where the EFE grid is preheated before the start of cranking to determine if that would shorten start times.

5.2.1.5 Analysis of Temperature Data

As previously stated, representative temperature plots were made for most significant engine parameters over the city and highway driving cycle. These traces are contained in total in Volume 2. Selected plots of interest are included here for convenience. Analysis of these traces yields the following information.

5.2.1.5.1 Stove Output and Carb-Air Inlet Temperatures

A comparison of the stove output temperature traces, illustrated in Figure 24, reveals that the full wrap stove and pin-fin exhaust manifold supply substantially hotter air to the heat control door during the 0°C (32°F) and -20°C (-4°F) runs than during the +25°C (77°F) runs. During bag 2 of the -20°C (-4°F) run, for example, Figure 25 indicates that the stove output temperature from the base vehicle averaged approximately 65°C (119°F), whereas the output from the EFE equipped vehicle averaged approximately 120°C (248°F).

In addition to increasing stove output temperature on the EFE vehicle, the full-wrap stove also provided a significantly faster temperature rise for the carburetor inlet air temperature during the cold transient portion of the test. Time for the carburetor air inlet temperature to reach 15°C (59°F) at a test temperature of -20°C (-4°F) was approximately 430 seconds for the production stove, vs 250 seconds for the full-wrap stove, or a 40% reduction in time for the full-wrap stove. (See Figure 26 of Carb-Air Inlet Temperature versus time for Vehicle #2).

During bags 2 and 3 of the city cycle at -20°C (-4°F), the full-wrap stove had no significant effect on carb-air inlet temperatures, as shown in Figures 27 and 28. In both base and modified configurations, carb-air inlet temperatures reached steady states of approximately 18°C (64.4°F).

It should be noted, however, that in the case of both other test vehicles, the carb-air inlet temperatures during the city cycle at -20°C (-4°F) were considerably lower than those of the base EFE vehicle, and steady state carb-air inlet temperatures were not achieved until the highway portion of the test. Application of the full-wrap stove to these other vehicles in the program, therefore, would probably have shown an even more dramatic improvement in stove performance than shown on the EFE vehicle.

The reason that the EFE vehicle in base form appears to have superior stove performance, compared to the other vehicles in the program, can probably be explained as follows. First, the EFE vehicle was a 2-door vehicle, whereas the other vehicles were both 4-doors. Due to vehicle front end styling differences, the air flow through the engine compartment is normally lower for the 2-door than for the 4-door, resulting in higher underhood temperatures and, possibly higher stove output and carb-air inlet temperatures. Secondly, other engine related variables such as exhaust gas temperature could have been significantly different between vehicles, resulting in the better stove performance of the 2-door vehicle.

Further analysis of the steady state carb-air inlet temperature for the EFE vehicle indicates an interesting phenomenon. Carb-air inlet temperatures consistently averaged 4°C (7°F) lower at -20°C (-4°F) than at 0°C (32°F). (See Figure 27.) This occurred in both base and modified configurations, indicating that the drop in carb-air inlet temperature at -20°C (-4°F) is probably not a result of insufficient stove output, but more likely the result of the heat control door sensor actually controlling the inlet air to a lower temperature at the -20°C (-4°F) test temperature.

Finally, it should be noted (see Figure 25) that the stove output temperatures for both the base and modified vehicle at a +25°C (77°F) test temperature were much lower than they were at the colder temperatures, and were, in fact, not very much above test cell temperatures. This probably occurred because the heat control door was in the fully closed position during test runs at +25°C (77°F), thereby allowing the air to "stagnate" in the stove-to-air cleaner duct. The stove output temperatures recorded would, therefore, not represent the capability of the stove, but rather the temperature of the stagnant air column in the duct in which the stove output thermocouple was located.

5.2.1.5.2 Intake Charge Temperature

The heated grid of the EFE system shuts off when engine coolant temperatures of approximately 66°C (150°F) are reached. This normally occurs at approximately 135 seconds, 190 seconds and 240 seconds into the cold transient portion of the city test cycle at test temperatures of +25°C, 0°C, and -20°C (77°F, 32°F, and -4°F) respectively.

Analysis of Figure 29, which shows the temperature of the intake manifold runner on the EFE vehicle, indicates a somewhat higher intake charge temperature for the EFE configuration when the heated grid is operating when compared to the base EFE vehicle.

One would expect that this increase in intake change temperature would be a result of both the full-wrap stove and the EFE heater grid. However, careful analysis of Figure 24 indicates that the full-wrap stove does not start to provide higher output temperatures than the production stove until approximately 120 seconds and 45 seconds into the test at -20°C (-4°F) and 0°C (32°F) respectively. This indicates that before that time the EFE grid is, in fact, responsible for the higher intake charge temperatures

5.2.1.6 Driveability

Results of driveability tests on the base and modified vehicle are shown in Table 29. Tests on the modified vehicle, which were run at temperatures 15-20C° (27-36F°) colder than the base vehicle, showed similar driveability ratings to the base vehicle. A detailed comparison of ratings between the base and modified car is not possible, however, because of the wide differences in test temperatures.

5.2.2 Engine Block Heat Conservation Configuration

5.2.2.1 Block Heater Preheat Tests on Base Vehicle

The purpose of these runs was to determine the relationship between block heater preheat time and vehicle fuel consumption. Referring to Table 30, city cycle fuel consumption improvements of 8, 10 and 6% were obtained for block heater preheat times of 4, 2½ and 1 hour respectively. The apparent contradiction in the fact that the 2½-hour block heater preheat time resulted in a greater improvement in fuel consumption than the 4-hour block heater preheat time can best be explained by looking at the fuel consumption data for each bag shown in Table 31.

For the 1-hour block heater preheat time, a 14% fuel consumption improvement was realized in bag 1. This was followed by a 2% loss in bag 2 and a 3% improvement in bag 3. Most, if not all, of the fuel consumption improvement, therefore, appears to come in bag 1. In both the 2½-hour and 4-hour block heater preheat times, a 23% improvement in fuel consumption is realized in bag 1. This implies that anything more than a 2½-hour preheat time does not affect bag 1 fuel consumption. However, in the case of the 2½-hour preheat time, a further 3% fuel consumption improvement is realized in bags 2 and 3, whereas with the 4-hour preheat time, there is essentially no change in bag 2 fuel consumption from the base car,and only a 2% improvement in bag 3. The improvement of 3% in bag 2 for the 2½-hour preheat time was enough to improve the overall fuel consumption of the 2½-hour preheat runs to give them almost a 2% edge over the 4-hour preheat runs. Had this 3% improvement not been realized in bag 2, then the overall fuel consumption for the 2½-hour block heater preheat time would have been the same as the 4-hour block heater time, implying that there is no fuel consumption benefit under these conditions for anything longer than a 2½-hour block heater preheat time.

Improvements in highway fuel consumption of 4%, 3% and 1% respectively for the 1-hour, 2½-hour and 4-hour preheat runs were also recorded (see Table 30). These improvements in highway fuel consumption seemed opposite to what one would expect. If the effect of the block heater did carry over into the highway portion of the test, then one would expect that with longer block heater preheat times, lower fuel consumption would be realized. However, the opposite was true. The lowest fuel consumption was obtained with the shortest preheat time. No logical explanation for this could be found. Test to test repeatability throughout the program had been consistently less than the 1½% coefficient of variation specification described earlier in the report. During the block heater runs, tests within each series of 1-hour, 2½-hour and 4-hour block heater preheat time were all very consistent with less than 0.5% coefficient of variation between highway runs. Only when the block heater preheat time was changed, did the highway fuel consumption change substantially.

In order to try and explain this phenomenon, average cell temperatures during all the tests were examined to see if these changed substantially between tests. This was not found to be the case. Crankcase oil and transmission fluid temperatures during the highway cycle (Figures 30 and 31) were also checked and eliminated as contributing factors to this phenomenon. In fact, in both cases fluid temperatures were consistently higher throughout the city and highway test for the 4-hour run than for the 2½-hour run, which in turn were higher than for the 1-hour run. This indicated that there was a slight carry over effect of the block heater into the highway cycle, which in this case did not seem to positively affect vehicle fuel consumption.

Because of this anomally and the apparent improvement in city bag 2 and 3 fuel consumption with 2½-hour block heater preheat time over the 4-hour time, it is recommended that more testing be done to further investigate the effect of block heater preheat times on city cycle bag 2 and 3, and highway cycle fuel consumption.

5.2.2.1.1 Comparison of Choke-on Times

Referring to Table 32, it can be seen that the block heater preheat time does have an affect on choke-on times. Compared to the base vehicle, choke-on times were reduced by 5%, 22% and 27% respectively for the 1-hour, 2½-hour and 4-hour block heater preheat times. Again, there seems to be a point of diminishing returns at approximately a 2½-hour block heater preheat time beyond which the block heater has minimal effect on choke-on times.

5.2.2.1.2 Comparison of Start Times

As shown in Table 33, the application of the block heater had a dramatic affect on start times. The length of time the block heater was turned on prior to a cold start, however, seemed to have virtually no effect, as long as at least 1-hour of preheat time was used.

5.2.2.1.3 Driveability

Driveability test results with 2½-hour and 1-hour block heater preheat times are shown in Table 34. There were no driveability runs done with a 4-hour block heater preheat time. As shown, the block heater had a significant effect on the start rating, with very fast starts and no die outs occurring for both the 1-hour and 2½-hour preheat runs. The block heater also had a significant effect on cold idle quality immediately after the engine was started, although this is not readily apparent from the cold idle ratings in the table since they represent an average idle rating for the 3 miles of driving in the test. The block heater did not significantly affect any other portion of the driveability test.

5.2.2.2 Test Runs with Engine Block Heat Conservation Modifications

Tests on this configuration were run at both "standard" and modified road load horsepower settings, the standard horsepower setting being that determined for emissions certification purposes for the 4-door body style using track coastdown techniques.

The first set of runs (Series 4.5), tested at $+25^{\circ}$C (77^{0}F) and -20°C (-4°F), were done using the "standard" road load horsepower settings used for all previous testing. These tests were run to isolate the effects of the engine block heat conservation modifications on engine efficiency, without taking into effect any aerodynamic benefits that may be gained by application of the winter front and under-engine pan.

The second set of tests, Series 4.7, were run at the same temperatures, but with modified road load horsepower settings to take into account the aerodynamic benefit of the modifications. As described earlier, the modified horsepower settings were arrived at by performing back-to-back track coastdown tests (see Appendix 11) on a similar vehicle with and without the winter front and under-engine pan assembly. Based on such tests, and a "standard" actual horsepower for a base vehicle of 7.9 HP at 80 km/hr (50 mi/hr), as used in test series 4.1, 4.4.X, 4.4.Y, 4.4.Z and 4.5, it was found that the actual road load horsepower at 80 km/hr (50 mi/hr) for the modified vehicle equipped with the winter front and under-engine pan should be 7.3 HP at $+25^{\circ}$C (77°F) for test series 4.7, which simulated operation with the winter front shutters fully open and 7.0 HP at -20°C (-4°F) for test series 4.7, which simulated operation with the winter front shutters fully closed.

When comparing the fuel consumption of the base and modified test vehicles,as summarized in Table 30 for test series 4.1 and 4.5 (both run at an actual horsepower of 7.9), we see an increase in fuel consumption of 1% at +25°C (77°F), followed by a decrease of 6% at -20°C (-4°F). Highway fuel consumption improved by 2% at +25°C (77°C) and 5% at -20°C (-4°F). The substantially improved fuel consumption at the colder test temperatures, compared to the +25°C (77°F) tests, was expected, since this package attempts to thermally insulate the engine from its surrounding environment. Therefore, the benefits with this package, compared to the base vehicle, should increase as ambient temperature decreases.

Also as indicated in Table 30 for test series 4.7, test results for the same vehicle with the revised horsepower settings showed improved fuel consumption across the board as expected, with fuel consumption decreases at -20°C (-4°F) reaching 8% in the city and 9% on the highway.

To more closely analyze the city cycle test results, it is necessary to look at both a bag breakdown of fuel consumption, as well as the pertinent temperature traces for the test results of interest. Referring to Table 31, it appears that at +25°C (77°F), there is a slight fuel consumption penalty in bag 1 for this package. Both runs 4.5 and 4.7 showed fuel consumption penalties of 4% and 2% respectively. However, this is partly regained by fuel consumption improvements in bag 3 of 2% in each case. The gains in bag 3 are probably a result of the heat retention capabilites of the test hardware maintaining heat within the engine during the 10 minute hot soak. This results in minimal differences in city cycle fuel consumption at +25°C (77°F) between the base and modified vehicle configurations.

At $-20^{\circ}C$ $(-4^{\circ}F)$, for both test series 4.5 and 4.7, fuel consumption improvements,in comparison to the base vehicle tests in test series 4.1, occur during all 3 bags. Largest improvements, however, occur in bags 1 and 3, where fuel consumption improvements over the base vehicle averaged double the improvements of bag 2. The relatively large improvement in bag 1 fuel consumption compared to bag 2 can be explained in two ways. First, referring to the Vehicle Cooldown Temperature Traces, Figure 32, and also to the Frost Plug Temperature versus Time traces, Figure 33, for the related runs, the engine insulation and winter front assembly maintained enough heat in the engine during the 15-hour soak period that at the start of the following city cycle test, the engine, in many cases, had not completely cooled down to the cell temperature. The second reason for the bag 1 fuel consumption improvement can be traced to the rise in block temperature after the cold start. With the block heat conservation modifications, the thermostat reached $90.5^{\circ}C$ $(195^{\circ}F)$ in approximately a 20% shorter time period than the base vehicle. See Figure 34.

Reasons for the large fuel economy improvements in bag 3 of the city cycle at $-20^{\circ}C$ $(-4^{\circ}F)$ probably resulted from increased heat retention in the engine compartment during the 10 minute hot soak,as a result of the engine insulation on the modified vehicle. This is shown graphically in the Frost Plug Temperature versus Time traces, Figure 35, where the vehicle with modifications maintained a slightly higher temperature $(5\text{-}10C^{\circ}$ $(9\text{-}18F^{\circ}))$ during the hot soak.

As stated earlier, highway fuel consumption improved over baseline by approximately 5% at $-20^{\circ}C$ $(-4^{\circ}F)$ for the modified vehicle in test series 4.5. Some of this gain in fuel consumption can probably be attributed to higher engine and driveline operating temperatures for the modified vehicle.

Referring to the graphs of Frost Plug Temperature versus Time, Crankcase Oil Temperature versus Time and Transmission Oil Temperature versus Time (Figures 36, 30, 31), it can be seen that coolant, engine oil, and transmission oil temperatures were all up substantially during the -20°C (-4°F) highway run compared to the base car run at -20°C (-4°F). Coolant temperatures (at the frost plug) were up approximately 7C° (12.6F°) on the modified car to about a 97°C (206.6°F) operating temperature. Engine oil temperatures were approximately 12C° (21.6F°) higher throughout the highway cycle for the modified vehicle, averaging about 105°C (221°F) during the cycle. Finally, transmission oil temperatures showed approximately a 28C° (50.4F°) spread in temperatures between the base and modified vehicle thoughout the highway cycle, averaging around 85°C (185°F) temperature for the modified vehicle. In all cases, temperatures throughout the highway cycle for the modified vehicle at -20°C (-4°F) were almost identical to the base vehicle temperatures at +25°C (77°F). At the +25°C (77°F) test temperature, the modifications resulted in only a slight increase in engine related temperatures compared to the base vehicle. Engine coolant, engine oil, and transmission oil temperatures were all up by approximately 8C° (14.4F°) for the modified vehicle compared to the base vehicle at +25°C (77°F). In other words, the modifications were quite successful in making engine and driveline operating temperatures on the highway cycle independent of ambient air temperatures.

As expected, fuel consumption figures for the vehicle with the modified (lowered) horsepower settings (test series 4.7), improved over the runs with the standard horsepower settings for both city and highway cycles, with greatest gains generally being obtained on the highway. Improvements in fuel consumption over the base vehicle of 0% and 8% for the city cycle at 0°C (32°F) and -20°C (-4°F) respectively, and 4% and 9% on the highway cycle at 0°C (32°F) and -20°C (-4°F) respectively were experienced as summarized in Table 30.

These tests with the lowered horsepower setting best represent the true fuel consumption potential of this vehicle, since the aerodynamic benefit of this package would automatically be realized during on-road driving.

5.2.2.2.1 Comparison of Choke-on Times

As shown in Table 32, the application of the block heat conservation modifications appeared to have a small effect on choke-on times, reducing these times to approximately the same levels as one hour of block heater preheat on the base vehicle.

5.2.2.2.2 Comparison of Start Times

As shown in Table 33, the application of the block heat conservation modifications appeared to have a detrimental effect on start times at -20°C (-4°F). No apparent reason for this increase can be found. If the modifications were resulting in increased fuel percolation or fuel vaporization during the soak period, then one would expect this to show up in the dynamometer tests at +25°C (77°F). This was not the case, as start times during these tests were very similar for both the base and modified vehicles.

Finally, start times recorded during the driveability tests on this configuration showed slightly shorter start times for the modified vehicle than for the base vehicle, the opposite of what was observed in the cold room. (See Section 5.2.2.2.4).

5.2.2.2.3 Analysis of Temperature Data

The affect of engine block heat conservation modifications on most engine related temperatures has already been discussed. Analysis will, therefore, be limited to the affect of the modifications on stove output and carb-air inlet temperatures.

5.2.2.2.3.1 Stove Output and Carb-Air Inlet Temperatures

Referring to the graphs of Stove Output Temperature versus Time,and Carb-Air Inlet Temperature versus Time, Figures 37 and 38, the modifications did have a significant affect on stove output and carb-air inlet temperatures. Stove output for the modified vehicle at -20°C (-4°F) was approximately 25C° (45F°) higher during bag 2 than on the base vehicle. This had a direct affect on the carb-air inlet temperature, which reached an operating temperature of approximately 20°C (36°F) by the end of bag 1 for the modified car, compared to the base vehicle which never reached a steady state operating temperature until the beginning of the highway cycle.

5.2.2.2.4 Driveability

Driveability test results with the winter front and related modifications are shown in Table 35. Improvements in driveability with the block heat conservation modifications on the vehicle were limited to slight improvements in starting ease and also cold idle quality after starting. These improvements may be a result of the heat retention capabilities of the package, maintaining some heat within the engine during the overnight soak. Other changes in vehicle driveability were minimal for the rest of the test.

5.2.2.3 Block Heater Warmup and Vehicle Cooldown Temperature Traces

Two sets of tests were run at an ambient temperature of -20°C (-4°F) to determine what effect, if any, the winter front and insulation package would have on (a) block heater warmup rates and (b) vehicle cooldown rates after a fully warmed-up vehicle is shut off. These tests involved no dynamometer runs; only temperature traces were made during the warmup and cooldown cycles.

Results of the first set of tests are shown in the Block Heater Warmup Temperature Traces (Figure 39). In interpreting the results, it should first be noted that both the base and modified car were not at the same temperature at the start of the test. It does appear, however, that the vehicle modifications did have a marked affect on some of the parameters measured. Thermostat temperature showed a steeper temperature rise for the modified vehicle than for the base vehicle, reaching a +20°C (68°F) temperature in 64 minutes versus 84 minutes for the base vehicle. In addition, the crankcase oil temperature appeared to stabilize at a somewhat higher temperature in the modified vehicle, reaching approximately 4°C (39.2°F) after 8 hours, compared to -5°C (23°F) for the base vehicle. No stabilized or equilibrium data is available for the thermostat temperature because of instrumentation problems that occurred during the test.

In summary, one would expect that the vehicle modifications tested would, to some extent, improve the effectiveness of the block heater when used prior to a cold start.

Results of the second set of tests are shown in the Vehicle Cool-down Temperature Trace (Figure 32). From the trace, it is apparent that the vehicle modifications did have a significant affect on the cool-down characteristics of the engine and related hardware. In the base vehicle,steady state temperatures were reached in approximately 10 hours, whereas in the case of the modified vehicle, stabilized temperatures had not been reached after 12½ hours when the test was stopped. These results are compared in Table 36.

As indicated in Table 36, stabilization* times during vehicle cool-down tests for the base configuration ranged from 300 minutes for the left load temperature to 630 minutes for the thermostat temperature. In contrast, stabilization times for the base vehicle ranged from 660-690 minutes.

Table 37 summarizes the final temperature of seven engine-related parameters for both the base and modified configurations of the engine block heat conservation vehicle after 10 hours of soaking at -20°C (-4°F). As indicated, final temperatures for the modified configuration were all significantly higher than those of the base configuration. Similarily, Table 38 details final temperatures of the same engine-related parameters after 8 hours of preheat with the block heater while soaking at -20°C (-4°F). As with the cooldown tests, Table 38 indicates that substantially higher final temperatures were obtained with the modified configuration after the 8-hour period.

These superior heat retention capabilites of the modified vehicle may therefore improve the effectiveness of the block heater in reducing fuel consumption after a cold start, depending on the soak time and ambient temperature.

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* stabilization time is defined here as the time to reach 90% of the final value

5.2.3 High Compression Configuration

The high compression vehicle was tested with three different spark calibrations (see Table 19). Calibrations A and C (Tests 5.2 and 5.4) had the same basic timing (15° BTDC) and zero time offset (16%) as the base car, with A having a coolant switch function and C not. Calibration B (Test 5.3) had a higher basic timing (22°) and higher zero time offset (25%) which provided additional spark advance over the driving cycle. It also incorporated a coolant switch function. Unfortunately, due to a wiring problem, the coolant switch function was rendered inoperative for all tests on the modified vehicle making calibrations A & C identical except for the start transient function (see Table 19).

Improvements in the city and highway cycle fuel consumption over the base vehicle are shown in Table 39. Improvements in fuel consumption will be analyzed separately for each spark calibration.

5.2.3.1 Calibration A (Prom #1 - Test Series 5.2)

Improvements in city cycle fuel consumption were approximately 6% at +25°C (77°F), 4% at 0°C (32°F), and 4% at -20°C (-4°F). Improvements in highway cycle fuel consumption were approximately 6% for all three test temperatures. Analysis of fuel consumption on a bag basis (Table 40) indicates that fuel consumption improvements were generally obtained in all 3 bags of the city cycle.

5.2.3.2 Calibration B (Prom #12 - Test Series 5.3)

As expected, the higher basic timing and zero time offset provided greater improvements in fuel consumption over the base vehicle than calibration A. Improvements in city cycle fuel consumption over the base vehicle averaged approximately 7% at +25°C (77°F) and 6% at 0°C (32°F). Improvements in highway fuel consumption averaged approximately 7% at +25°C (77°F) and 8% at 0°C (32°F). There were no city or highway tests run at -20°C (-4°F) for this calibration.

5.2.3.3 Calibration C (Prom #2 - Test Series 5.4)

Improvements in city cycle fuel consumption over the base vehicle were exactly the same at +25°C (77°F) as for Calibration A. However, at 0°C (32°F) and -20°C (-4°F), improvements averaged 5% and 7% respectively over the base car, or slightly higher than the 4% improvement at both temperatures for Calibration A. These improvements over Calibration A were unexpected, since, as discussed earlier, Calibration A and C were almost identical. Some of this difference in fuel consumption can be explained by examining the bag results .

At 0°C (32°F), the difference in city cycle fuel consumption between Calibration A & C is largely a result of the difference in bag 3 fuel consumption, where Calibration A actually shows a 2% fuel consumption penalty over the base vehicle versus a 5% improvement for Calibration C. The average 2% penalty on calibration A was caused by high fuel consumption in Bag 3 for one run only, which may represent a test outlier rather than any real differences between calibrations A and C.

At -20°C (-4°F), the fuel consumption benefit of Calibration C over A occurs almost entirely in bag 1, with an 11% improvement in fuel consumption over the base car for Calibration C, versus only a 2% improvement for Calibration A. This improvement appears to occur primarily at the end of bag 1 (see Fuel Consumption versus Time plot for this vehicle, Figure 40) after the start transient spark advance has decayed to zero and is, therefore, probably unrelated to spark timing. No logical explanation can be found for this improvement in fuel consumption over Calibration A.

Improvements in highway fuel consumption for Calibration C, relative to the base vehicle, were similar to those with Calibration A. Fuel consumption improved by approximately 6% at +25°C (77°F), 5% at 0°C (32°F) and 6% at -20°C (-4°F).

5.2.3.4 General Trends

In most cases,it appears that there may be a slight decrease in the benefits of high compression with decreasing temperature. In 2 of the 3 calibrations tested, the city cycle fuel consumption improvement over the base vehicle decreased at lower test temperatures. Improvements in highway fuel consumption, however, appeared to be independent of test temperatures.

5.2.3.5 Driveability

Driveability tests were performed on the base vehicle and high compression vehicle with spark calibrations A and B. Due to lack of time, no tests were performed on Calibration C. Results of the driveability tests (see Table 41) show similar driveability ratings, in most cases for the base and modified configurations. Only in the cold start ratings were major differences recorded between configurations,and this can be attributed to the widely varying weather conditions between tests.

5.2.4 Other Findings of Phase 1

During the course of the testing program, a number of engine variables were monitored between the city and highway cycle of the test to ensure that the vehicles were operating properly. To do this, the vehicle was put into neutral immediately after the city cycle and a number of items, including engine idle speed, were recorded. One interesting phenomenon that emerged was that engine curb idle speed seemed to be somewhat related to ambient temperature. All three base vehicles showed idle speed increases, in most cases, of approximately 100 rpm at -20°C (-4°F) compared to the idle speeds at +25°C (77°F) and 0°C (32°F).

A definite reason for this increase has yet to be found. In all cases, spark timing was checked and found to be within specifications. Other possible causes for this include carb air inlet temperature, which in most cases was lower at 20°C than at 0°C, and fuel temperature, which by design was controlled to the cold room temperature. It is hoped that more testing can be done in the future to isolate the different engine variables and determine the cause of the idle speed increase. Obviously, this has significant implications on cold weather fuel consumption.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.1.1

The block heat conservation modifications provided the greatest overall improvement in fuel consumption at -20°C(-4°F) of all the configurations tested. Fuel consumption improvements compared to the base car of approximately 8% for the city and 9% for the highway were recorded at this temperature. Fuel consumption improvements of 0% for the city and 4% for the highway were recorded at the +25°C (77°F) test temperature. Approximately 50% of the highway improvement and 30% of the city improvement recorded at both temperatures was a result of the aerodynamic benefit of the winter-front and under-engine pan.

6.1.2

The optimum block heater preheat time for the best fuel consumption after a cold start was determined to be in the region of 2½ hours. For this preheat time the fuel consumption improvement was approximately 10% for the city cycle at a test temperature of -20°C(-4°F). Small improvements in fuel consumption were also realized for the highway cycle at this temperature.

6.1.3

The high compression configuration provided city and highway fuel consumption improvements of 4%-8% over the base car at all test temperatures.

6.1.4

The EFE configuration provided significant improvements in city cycle fuel consumption at -20°C(-4°F) with the greatest improvement being obtained in bag 1 of the cycle. A fuel consumption improvement of 18% for bag 1 and 6% overall for the city cycle was recorded at -20°C(-4°F). The EFE configuration showed a 1% improvement at 0°C(32°F) and a 4% penalty in city cycle fuel consumption at 25°C(77°F). The penalty at 25°C (77°F) was attributed primarily to a shift in the vehicle baseline. Highway cycle fuel consumption was not significantly affected at any test temperature.

6.1.5

The greatest improvement in vehicle driveability was obtained with the use of an engine block heater prior to a cold start. Engine block heat conservation and high compression modifications did not have any significant effect on the vehicle driveability ratings. Early fuel evaporation modifications only improved initial idle quality.

6.1.6

The block heat conservation modifications significantly lengthened the cool-down time of the engine during the soak period at cold temperatures. Test data indicates that, on the average, stabilization times for the modified configuration were 40% longer than for the base configuration at a soak temperature of -20°C(-4°F). Engine block heater warm-up tests showed similar trends with some temperatures in the modified configuration reaching a stabilized value in a 25% shorter time period. In all cases, critical engine and drive train temperatures throughout the highway cycle for the modified vehicle at a test temperature of -20°C (-4°F) were almost identical to the base vehicle temperatures at a test temperature of +25°C (77°F).

At the +25°C(77°F) test temperature, the modifications resulted in only a slight increase in engine related temperatures compared to the base vehicle.

6.1.7

In most cases, engine idle speed for a fully warmed-up vehicle increased by approximately 100 RPM for all test vehicles at the -20°C (-4°F) test temperature compared to 0°C (32^{0}F) and +25°C (77°F) test temperatures. The cause of this observed change in idle speed was not determined.

6.2 Recommendations for Future Work

6.2.1

The fact that the city and highway fuel consumption savings did not follow the expected trends, with block heater preheat time suggests that extraneous factors might have been involved. Further work should be directed in this area to fully establish the relationship between block heater preheat time and fuel consumption savings.

6.2.2

It was established that all configurations tested yeilded fuel consumption improvements when tested at -20°C (-4°C). However, the early fuel evaporation modification resulted in a slight increase in fuel consumption over the base vehicle at +25°C (77°F). Further development and testing of this configuration is, therefore, required.

6.2.3

Although low temperature fuel consumption savings in the order of 4% - 10% were determined for each configuration, the effects of each configuration on exhaust emissions were not determined. A future study should be undertaken to investigate the effects of these vehicle modifications on HC, CO, and NO_x emissions as a function of test temperature.

6.2.4

Increases in idle speed as observed on all vehicles in this project at the -20°C (-4°F) test temperature could have a significant affect on cold weather fuel consumption. Additional work is needed to isolate the cause of this phenomenon and quantify the effects.

6.2.5

Further work should include runs on EFE configurations in which the grid is preheated before the start of cranking, to determine the effect of EFE preheating on start times.

REFERENCES

1. Test Fuel Specifications Report Q.E.T.E.
2. 1979 Horizon/Omni, Chassis Body Service Manual
3. Motor Vehicle Fuel Consumption Test Methods
4. Motor Vehicle Emissions Test Methods

VEHICLE NO.	V.I.N. (Last 6 Digits)	CONFIGURATION NO.	CONFIGURATION
2	107326	2	Early Fuel Evaporation
4	117590	4	Engine Block Heat Conservation
5	109222	5	High Compression

Table 1 - Test Vehicle Identification

TESTS	RESULTS
Octane, Research min	91.8
Octane, Motor, min	97.9
Density (at 15°C/60°F) kg/L (lbm/ft^3)	0.7003 kg/L (43.7 lbm/ft^3)
Lead Organic mg/L (lbm/ft^3)	0.71 mg/L (.04 lbm/ft^3)
Distillation Range	
IBP, °C	29
10%, °C	40
50%, °C	66
90%, °C	128
E.P., °C	182
Sulfer, max (%)	0.03
Phosphorus, max mg/L (lbm/ft^3)	0.0004 mg/L (2.5×10^{-5} lbm/ft^3)
RVP (read vapour pressure)	92.7
Olefins, max (%)	3.4
Aromatics, max (%)	14.9
Saturates (%)	81.7
MMT as M_n	N/A
Existent Gum mg/100 mL (lbm/ft^3)	4.1 mg/100 mL (2.6 lbm/ft^3)
Colour	Straw
Appearance	Clean and Clear

Table 2 - Test Fuel Specifications

THERMO-COUPLE NO.	LOCATION	CONFIGURATION NO.			THERMO-COUPLE TYPE	PROBE* TYPE	PROB mm OR W
		2	4	5			
60	Frost Plug		X		T	S	3.18
61	Thermostat	X	X	X	T	S	"
62	Lower Rad Hose		X		T	S	"
63	Vernatherm (Winter Front)		X**		T	S	"
64	Engine Oil at Dipstick	X	X	X	T	E	.51
65	Carb Air In	X	X	X	T	E	"
66	Ambient	X	X	X	T	E	"
67	Fuel	X	X	X			
68	Stove Output	X	X		T	E	"
90	Fresh Air Duct	X			T	E	"
91	Lower Air Cleaner	X			T	E	"
92	Intake Manifold Floor	X			T	E	"
93	Intake Manifold Runner	X			T	E	"
94	Tailpipe			X†	T	E	"
95	Right Hood		X		T	E	"
96	Left Hood		X		T	E	"
99	Transmission at Dipstick	X	X	X	T	E	"
75	Glycol (PAU Outlet)	Not On Vehicles					
80	Left Inertia Wt Enclosure						
81	Drivers Aid Heat. Encls.						
82	Right Inertia Wt Enclosure						
83	PAU Enclosure						
84	Fuel Canister						

NOTES: * Probe Types: S - Stainless Steel Sheath with Grounded Junction
E - Exposed Wire with Bead Type Junction

** Only with Winter Front Installed

† Only up to Test 5.1.4

SHEATH nches) RE DIA.	LOCATION DETAILS
.125")	Right Rear Frost Plug
"	Thermostat Housing
"	At Outlet of Rad
"	At Inlet of Vernatherm Unit
.020")	At Tip of Dipstick
"	1" Upstream of Heated Air Door Sensor
"	At Right Front Drip Rail
	See Figure 1
"	In Stove Duct Approx. 3" Below Entrance to Air Cleaner
"	At Entrance to Air Cleaner
"	On Front Side of Air Cleaner, 1" Up From Floor Between Filter Element and Air Cleaner Wall
"	Located in Casting, Below Carb Primary
"	In #4 Runner 2" from Cyl. Head
"	6" From End of Tailpipe
"	Underhood-In Front of Block 2" Above Fuel Pump
"	Underhood-3" Behind Rad Fan
"	At Tip of Dipstick

Table 3 - Thermocouple Types & Locations

NUMBER		INSTRUMENTATION/SENSOR		
	SENSED PARAMETER	MANUFACTURER/DESCRIPTION	MODEL #	SERIAL #
1	TAILPIPE CO	HORIBA-INFRARED EXHAUST ANALYSER	MEXA 300A	104745
2	BATTERY VOLTAGE	CABLE TO VEHICLE BATTERY	-	-
3	MANIFOLD VACUUM	SCHAEVITZ-READOUT & PRESSURE TRANSDUCER	MTDR-3505 P724-0001	406 12633
4	CHOKE POSITION	BECKMAN ROTARY POTENTIOMETER	TSP R1KL.5	8024
5	ENGINE SPEED	SNAP-ON-MAGNETIC PICKUP AND METER WITH OUTPUT	MT455A	2975
6	IGNITION TIMING	SNAP-ON-INDUCTANCE PICKUP AND METER WITH OUTPUT	MT455A	2975
7	FUEL PRESSURE	SCHAEVITZ-READOUT & PRESSURE TRANSDUCER	MTDR-3505 P723-0001	407 10926

TABLE 4 - VEHICLE PARAMETER SENSORS

NO.	MANUFACTURER	DESCRIPTION	APPLICATION	MODEL NO.	SERIAL NO.
1	DIGITEC	Datalogger System with Options	Recording of Fuel Consumed, Dyno Roll Revs, % RH, Fuel Pressures, All Thermocouples	3000-2	47290612
2	WATANABE	6 Channel Analog Recorder	Record of Vehicle Parameters 1. Tailpipe CO 2. Battery Voltage 3. Manifold Vacuum 4. Choke Position 5. Engine Speed 6. Ignition Timing	MC6612-6H	98511015
3	SARTORIOUS	Weigh Scale 30000 gm Connector for digital output Interface Box	Measurement of Fuel Consumed Interface to Digitec	3806MP 1056-01 7053-05	B1229-105 B1229-191 2906065
4	SPECTRAL DYNAMICS	Fibre optic Tachometer Head Assembly Electronics	Dyno Roll Revs	SD43-GPT-1 13134 13135	1052 1139
5	DATA-PRECISION	Pulse totalizer	Count of Dyno Roll Revs	5740	10733
6	HORIBA	Infrared Exhaust Analyser CO 0→2%/0→10% HC 0→400 ppm/0→2000 ppm	Tailpipe CO & HC	MEXA 300A	104745

TABLE 5 - EQUIPMENT / INSTRUMENTATION

NO.	MANUFACTURER	DESCRIPTION	APPLICATION	MODEL NO.	SERIAL NO.
7	EG & G DEW-ALL	Digital Humidity Analyser & Display	% Relative Humidity Dew Point	911	0298
8	DAVIS ENGINEERING	Mass Storage Data Recorder	Magnetic Tape Record of Data on Digitec		
9	CLAYTON	Dynamometer Road Load Power Control	Vehicle Road Load Simulation Dynamometer Control	CTE50 A-34064-3-486	
10	TRANSPORT CANADA	Coast Down Timer	Dynamometer Frictional Horsepower Determination		1
11	AESI	Drivers Aid Recorder	Driving Cycle Display & Permanent Record	DA 1750	38632
12	MARQUETTE	Engine Analyser	Scheduled Vehicle Maintenance	40276	457432
13	CLIPPARD KENT-MOORE	Propane Enrichment Kit	Carburetor Idle Mixture Setting	MJV-2 J26911	
14	HEWLETT PACKARD	Digital Voltmeter	Dyno Calibration and Instrumentation Trouble Shooting	3490A	1211A02889
15	HEWLETT PACKARD	BIPOLAR Power Supply	Dyno Calibration	6825A	1612A00316
16	HEWLETT PACKARD	X-Y Plotter	Dyno Calibration	7046A	
17	GOULD	Oscilloscope	Dyno Calibration	0S3300B	661

TABLE 5 - EQUIPMENT / INSTRUMENTATION (CONT'D)

NO.	MANUFACTURER	DESCRIPTION	APPLICATION	MODEL NO.	SERIAL NO.
18	CALCOMP	X-Y Plotter	Plotting of Digitec Data	862811100	853934
19	CANLAB GCA PRECISION SCIENTIFIC	Stopwatch Stopwatch	Driveability Testing and Dyno Test Elapsed Times	69320	
20	BUFFALO	Cooling Fans 5000 CFM 18" Special	Vehicle Engine & Tire Cooling during Dyno Test	G400	76-M-426
21		Safety Straps 15" c/w hooks	Test Vehicle Tie-Down During Dyno Testing	13P	
22	WABASH	Battery Charger	Recharge Vehicle Battery	B-10A	
23	AO DUO CHECK	Battery & Coolant Tester	Test Battery and Engine Coolant	7181	
24	MARQUETTE	Vacuum Tester	Test Engine Vacuum	41-221	
25	PRECISION	Tire Pressure Gage 0 - 60 psi	Measure Vehicle Tire Pressure		
26	DUPREE	Electric Fuel Pump	Fuel Supply Pump	12V801	
27	FISHER CONTROLS	Fuel Pressure Regulator 2 - 6 psi	Limit Fuel Supply Line Pressure	95L	
28	HOLLEY	Fuel Pressure Regulator	Limit Carb.-in-fuel Pressure	34R-66578	
29	ASHCROFT	Pressure Gage	Fuel Pressure		
30		Fuel Canisters	Fuel Storage		

TABLE 5 - EQUIPMENT / INSTRUMENTATION (CONT'D)

NO.	MANUFACTURER	DESCRIPTION	APPLICATION	MODEL NO.	SERIAL NO.
31	SWAGELOCK	Fittings, valves, quick disconnects	Fuel Supply System		
32	TYGON	Clear Flexible Tubing	Fuel Supply System		
33	CHRYSLER	SOLENOID VALVE	Fuel Bypass	4085397	
34	AUSTIN	MINI	Dyno Warmup Vehicle		
35	FORD	PINTO	Dyno Coastdown Vehicle		
36	BISHMAN	Air Hydraulic End Lift	Dyno coastdowns	420	281
37	HEWLETT PACKARD	Digital Voltmeter	Dynamometer Electrical Calibration		

TABLE 5 - EQUIPMENT / INSTRUMENTATION (CONT'D)

PARAMETER / TEST RUN	2.1.2-4	2.1.3-1	2.1.4-1	2.2.2-1	2.2.3-2	2.2.4-3
Thermostat Temperature	✓	✓	✓	✓	✓	✓
Oil Temperature	✓	✓	✓	✓	✓	✓
Carb Air Inlet Temp.	✓	✓	✓	✓	✓	✓
Stove Output Temp.	✓	✓	✓	✓	✓	✓
Fresh Air Duct Temp.	✓	✓	✓	✓	✓	✓
Lower Air Cleaner Temp.	✓	✓	✓	✓	✓	✓
Intake Manifold Floor Temperature	✓	✓	✓			
Intake Manifold Runner Temperature	✓	✓	✓	✓	✓	✓
Fuel Consumed	✓	✓	✓	✓	✓	✓

Table 6 - Summary of Parameters Plotted for Fuel Consumption Tests of the Early Fuel Evaporation Configuration (Vehicle 2)

TEST RUN PARAMETER	4.1.2-3	4.1.4-4	4.3.X-1	4.4.Y-1	4.4.Z-2	4.5.2-2	4.5.4-2	4.7.2-1	4.7.4-2
Frost Plug Temperature	✓	✓	✓	✓	✓	✓	✓	✓	✓
Transmission Oil Temperature	✓	✓	✓	✓	✓	✓	✓	✓	✓
Left Hood Temperature	✓	✓*	✓	✓	✓	✓	✓	✓	✓
Right Hood Temperature	✓	✓	✓	✓	✓	✓	✓	✓	✓
Stove Output Temperature	✓	✓	✓	✓	✓	✓	✓	✓	✓
Carb. Air Inlet Temperature	✓	✓	✓	✓	✓	✓	✓	✓	✓
Oil Temperature	✓	✓	✓	✓	✓	✓	✓	✓	✓
Vernatherm Temperature						✓	✓	✓	✓

* Bag 3 and Highway Only

TABLE 7 - SUMMARY OF PARAMETERS PLOTTED FOR FUEL CONSUMPTION TESTS OF THE BLOCK HEAT CONSERVATION CONFIGURATION (VEHICLE 4)

PARAMETER	4.1.2-3	4.1.4-4	4.3.X-1	4.4.Y-1	4.4.Z-2	4.5.2-2	4.5.4-2	4.7.2-1	4.7.4-2
Lower Rad Temperature	✓	✓	✓	✓	✓	✓	✓	✓	✓
Thermostat Temperature	✓	✓	✓	✓	✓	✓		✓	✓ **
Fuel Consumed	✓	✓	✓	✓	✓	✓	✓	✓	✓

** Bag 1 only

TABLE 7 SUMMARY OF PARAMETERS PLOTTED FOR FUEL CONSUMPTION TESTS FOR BLOCK HEAT CONSERVATION CONFIGURATION (VEHICLE 4) (CONT'D)

PARAMETER RUN	FUEL CONSUMED (grams)
5.1.2-1	✓
5.1.3-1	✓
5.1.4-1	✓
5.2.2-1	✓
5.2.3-3	✓
5.2.4-2	✓
5.3.2-1	✓
5.3.3-3	✓
5.4.2-2*	✓
5.4.2-2**	✓
5.4.4-2	✓

TABLE 8 - SUMMARY OF HIGH COMPRESSION CONFIGURATION FUEL CONSUMPTION PLOTS (Vehicle #5)

* Bag 2 Not Plotted

** Bag 3 and Highway Not Plotted

PARAMETER	COOLDOWN		WARM UP	
	BASE	MODIFIED	BASE	MODIFIED
Transmission Oil Temperature	✓	✓	✓	✓
Left Hood Temperature	✓		✓	
Stove Output Temperature	✓	✓	✓	✓
Carb Air Inlet Temperature	✓	✓	✓	✓
Oil Temperature	✓	✓	✓	✓
Frost Plug Temperature		✓		✓
Thermostat Temperature	✓	✓	✓	✓ *

* Not complete

TABLE 9 - SUMMARY OF PARAMETERS PLOTTED FOR COOLDOWN AND WARMUP TESTS (VEHICLE 4)

PARAMETER	CHANNEL NO.	PEN COLOUR	RECORDER SCALE	EQUIVALENT PARAMETER SCALING
TAILPIPE CO	1	Red	100 mV	.067%/cm (.17%/inch)
Battery Voltage	2	Black	20 V	.79 V/cm (2 V/inch)
Manifold Vacuum	3	Purple	200 mV	5.3 kPa/cm(4 inches Hg/inch)
Choke Position	4	Brown	2 V	LHS-Open, RHS-Closed
Spark Advance	5	Blue	100 mV	3.9 Deg/inch (10 Deg/inch)**
Engine Speed	6	Green	100 mV	270 rpm/cm (687 rpm/inch)*

* scale changed to 394 rpm/cm (1,000 rpm/inch) Jan.12, 1981

** scale changed Jan. 12, 1981

Table 10 - Watanabe Recorder Output & Scaling

Table 11 - Test Number Interpretation

EXAMPLE TEST NO.: 4. 1. 2 - 3

VEHICLE NO.:

2 = E.F.E. Vehicle

4 = Engine Block Heat Conservation Vehicle

5 = High Comp.Vehicle

TEST SERIES:

1 = Tests on Base Vehicle

2-7 = Tests with Exp. Hardware

TEST TYPE AND TEMP:

1 = On-Road Driveability at Prevailing Temperature

2 = City & Hwy Cycle @ +25°C

3 = City & Hwy Cycle @ 0°C

4 = City & Hwy Cycle @ -20°C

X, Y, Z = City & Hwy Cycle @ -20°C with Block Heater Pre-heat Time of 4 hrs, 2½ hrs., and 1 hr., respectively

TEST RUN NO:

Identifies Individual Run No. (Max. of 4 runs done for each combination of the above items)

0 = Preconditioning Run

1,2,3... = Test Run

V.I.N. 107520

VEHICLE #2 EARLY FUEL EVAPORATION I

TEST NUMBER	HARDWARE CONFIGURATION	TESTING PERFORMED	TEST TEMPERATURE °C (°F)
2.1.1	Base Vehicle	Driveability	-2 (28)
2.1.2	Base Vehicle	Fuel Consumption-Dynamometer	25 (77)
2.1.3	Base Vehicle	Fuel Consumption-Dynamometer	0 (32)
2.1.4	Base Vehicle	Fuel Consumption-Dynamometer	-20 (-4)
2.2.1	With EFE Heater Grid, Pin-Fin Exhaust Manifold, Full Wrap Stove & Recalibrated Choke	Driveability	-18 (-4)
2.2.2		Fuel Consumption-Dynamometer	25 (77)
2.2.3		Fuel Consumption-Dynamometer	0 (32)
2.2.4		Fuel Consumption-Dynamometer	-20 (-4)
2.2.5	Same as 2.2.4 above with EFE Powered Externally	Fuel Consumption-Dynamometer	-20 (-4)
2.D.1	Same as 2.2.1 above with modifications to carburetor to achieve better driveability (diagnostic tests)	Driveability	0 (32)
2.D.X	Same as 2.2.2 above	Fuel Consumption-Dynamometer	25 (77)
2.D.Y	Same as 2.1.2 above, but with Pin-Fin Exhaust Manifold and Full Wrap Stove	Fuel Consumption-Dynamometer	25 (77)
2.3.2	Retest of Modified Vehicle (same mods. as 2.2 above) after repairs	Fuel Consumption-Dynamometer	25 (77)
2.3.3		Fuel Consumption-Dynamometer	0 (32)
2.3.4		Fuel Consumption-Dynamometer	-20 (-4)

TABLE 12 - Summary of Tests Performed on Vehicle #2 - EFE

V.I.N. 117590

VEHICLE #4 ENGINE BLOCK HEAT CONSERVATION

TEST NUMBER	HARDWARE CONFIGURATION	TESTING PERFORMED	TEST TEMPERATURE ^{o}C (^{o}F)
4.1.1	Base Vehicle	Driveability	-3 (26.6)
4.1.2	Base Vehicle	Fuel Consumption-Dynamometer	+25 (77)
4.1.4	Base Vehicle	Fuel Consumption-Dynamometer	-20 (-4)
4.2	Base Vehicle - Block Heater	Cooldown & Block Heater Warmup traces	-20 (-4)
4.3.X	Base Vehicle - Block Heater on 4-Hrs. prior to test	Fuel Consumption-Dynamometer	-20 (-4)
4.3.1 4.4.Y	Base Vehicle - Block Heater on 2½-Hrs. prior to test	Driveability Fuel Consumption Dynamometer	-9 (15.8) -20 (-4)
4.4.1 4.4.Z	Base Vehicle - Block Heater on 1-Hr. prior to test	Driveability Fuel Consumption-Dynamometer	-24 (-11.2) -20 (-4)
4.5.1	With Winter front, Engine Insulation, Under Engine Pan, and No Bleed Thermostat	Driveability Fuel Consumption-Dynamometer Fuel Consumption-Dynamometer	-5 (23) +25 (77) -20 (-4)
4.6	With Winter front, Engine Insulation, Under Engine Pan, and No Bleed Thermostat	Cooldown & Block Heater Warm-up Traces	-20 (-4)
4.7.2 4.7.4	With Winter front, Engine Insulation, Under Engine Pan, No Bleed Thermostat, and Lower Road Load HP Setting	Fuel Consumption-Dynamometer Fuel Consumption-Dynamometer	+25 (77) -20 (-4)

TABLE 13 - SUMMARY OF TESTS PERFORMED ON
VEHICLE #4 - BLOCK HEAT CONSERVATION

V.I.N. 109222

VEHICLE #5 HIGH COMPRESSION

TEST NUMBER	HARDWARE CONFIGURATION	TESTING PERFORMED	TEST TEMPERATURE ^{O}C (^{O}F)
5.1.1	Base Vehicle	Driveability	-7 (19.4)
5.1.2	Base Vehicle	Fuel Consumption-Dynamometer	+25 (77)
5.1.3	Base Vehicle	Fuel Consumption-Dynamometer	0 (32)
5.1.4	Base Vehicle	Fuel Consumption-Dynamometer	-20 (-4)
5.2.1	High Compression-Spark Advance Prom #1	Driveability	-14 (68)
5.2.2		Fuel Consumption-Dynamometer	+25 (77)
5.2.3		Fuel Consumption-Dynamometer	0 (32)
5.2.4		Fuel Consumption-Dynamometer	-20 (-4)
5.3.1	High Compression - Spark Advance - Prom #12	Driveability	+3 (37.4)
5.3.2		Fuel Consumption-Dynamometer	+25 (77)
5.3.3		Fuel Consumption-Dynamometer	0 (32)
5.4.2	High Compression - Spark Advance - Prom #2	Fuel Consumption-Dynamometer	+25 (77)
5.4.3		Fuel Consumption-Dynamometer	0 (32)
5.4.4		Fuel Consumption-Dynamometer	-20 (-4)

TABLE 14 - SUMMARY OF TESTS PERFORMED ON VEHICLE #5
HIGH COMPRESSION

Table 15 - Base Vehicle Specifications

DESCRIPTION	SPECIFICATION
GENERAL	
Engine	1.7 L, 8.2:1 CR Nom.
Transmission	3 Speed Automatic
Axle Ratio	3.48:1
Carburetor	Holley 5220 Series
Chrysler P/N (Carb)	5214324
BASE TIMING	
Ignition Timing (basic)	15° BTDC
Idle Speed	900 rpm
Propane Enriched Idle Speed	1000 rpm
Hot Fast Idle Speed	1700 rpm
Throttle Stop Speed	700 rpm
Vacuum Kick	0.040"
Choke Index	2 notches rich
Fast Idle Cam Index	0.040"
ESA UNIT SPARK TIMING CHARACTERISTICS	
ESA P/N	5206 784
Start-Up Advance	
- initial	5°
- @ 55 seconds	0°
Vacuum Advance	
- Count up time	400 sec.
- Count down time	200 sec.
- Zero time offset	16% of available advance
- Vacuum range	0-10" Hg
- Full spark Advance	25°
- Vacuum Source	Manifold

CONT'D.

Table 15 - Base Vehicle Specifications
(Cont'd.)

DESCRIPTION	SPECIFICATIONS
ESA UNIT SPARK TIMING CHARACTERISTICS	
Governor Advance	
- 1000 engine rpm	0°
- 2000 engine rpm	10°
- 6000 engine rpm	20°
Speed/Vacuum Modulation	
- degrees at engine rpm	7° @ 1100 16° @ 1700 25° @ 2300
Notes - Timing Specifications 1. Vacuum and governor advance are additive to basic timing. 2. The clock functions (count-up time, count-down time and zero time offset) scale the vacuum advance curve. The clock function acts directly on the vacuum advance curve and provides a percentage of vacuum advance available depending on how long the carb idle contact switch has remained open or closed. 3. Governor and vacuum spark advance curves are essentially linear between the points specified. 4. The coolant switch cancels all vacuum advance at coolant temps. below approximately 65.5°C (150°F)	

COIL	EXPERIMENTAL COIL #300	PRODUCTION COIL #501
Nominal Torque, N.M/degree (in. oz/degree)	5.86×10^{-4} (.083)	9.89×10^{-4} (.140)
Nominal Activity, degrees/°C (degrees/°F)	2.34 (1.30)	1.44 (.80)
Coil Material (T.I.#)	P675 *	B1*
Nominal Coil Width, cm (in)	0.953 (.375)	0.953 (.375)

* B1 material will normally have 30%-40% slower timing specifications than the P675 material.

Table 16 - Choke Bi-Metallic Coil Specifications

MATERIAL PROPERTY	TEMPERATURE		
	-17.8°C (0°F)	93.3°C (200°F)	315.6°C (600°F)
K $\frac{W}{m - {}^{o}C}$ $(\frac{BTU}{hr\text{-}ft\text{-}{}^{o}F})$	.0510 (.0295)	.0685 (.0396)	.0872 (.0504)
C_P $\frac{J}{Kg - {}^{o}C}$ $(\frac{BTU}{lb\ {}^{o}F})$	770.5 (0.184)	837.5 (0.200)	942.1 (0.225)

Table 17 - Thermal Properties for Chrysler Insulating Material CR95

	WITH STANDARD PISTONS	WITH "HIGH COMPRESSION" PISTONS
Nominal Compression Ratio	8.2:1	9.3:1
Actual* Compression Ratio	8.23:1	9.52:1

*Measured with approximately 10,000 km (6,200 miles) carbon accumulation on cylinder head only; pistons were clean and free of carbon deposits.

Table 18 - Compression Ratios of High Compression Vehicle

		CALIBRATION "A"	CALIBRATION "B"	CALIBRATION "C"
CONFIGURATION	BASE VEHICLE	5.2	5.3	5.4
		PROM #1	PROM #12	PROM #2
Spark Advance During Cranking (°) BTDC	10	10	10	10
Basic Timing (°) BTDC	15	15	22	15
Coolant Switch (Y/N)	Y	Y*	Y*	N
Max Advance (°) BTDC	N/A	50	50	50
Governer Advance (° @ rpm)	0 @ 1,000	0 @ 1,000	0 @ 2,000	0 @ 1,000
	10 @ 2,000	5 @ 1,500	4 @ 2,400	5 @ 1,500
	20 @ 6,000	7 @ 2,000	4 @ 3,000	7 @ 2,000
		11 @ 2,500	8 @ 3,400	11 @ 2,500
		11 @ 3,000	8 @ 3,800	11 @ 3,000
		15 @ 3,500	10 @ 4,000	15 @ 3,500
Vacuum Advance (° @ "Hg")	0° @ 0"	0° @ 3"	0° @ 3"	0° @ 3"
	25° @ 10"	20° @ 10"	18° @ 11"	20° @ 10"
			18° @ 14"	
			20° @ 15"	
Start Transient	5° Initial tapering to 0° @ 55 sec (exponential)	5° for 15 sec. tapering to 0° @ 60 sec (linear)	5° for 15 sec tapering to 0° @ 60 sec (linear)	None
Speed/Vac Limited Advance (° @ rpm)	7 @ 1,100	7 @ 1,100	7 @ 1,100	7 @ 1,100
	16 @ 1,700	16 @ 1,700	16 @ 1,700	16 @ 1,700
	25 @ 2,300	20 @ 2,300	20 @ 2,300	20 @ 2,300
Vacuum Accumulator				
- Zero Time Offset	16%	16%	25%	16%
- Count Up Time (sec)	400	400	400	400
- Count Down Time (sec)	200	200	200	200

* After the Testing Program, it was determined that due to a wiring problem, the coolant switch was rendered inoperative for Tests 5.2 and 5.3

TABLE 19 - SPARK SCHEDULE FOR HIGH COMPRESSION 1.7L ENGINE

TEST NO.	CONFIGURATION	AVERAGE FUEL CONSUMPTION Litres/100 km (mi/imperial gallon)					
		25°C (77°F)		0°C (32°F)		-20°C (-4°F)	
		CITY	HWY	CITY	HWY	CITY	HWY
2.1	Base Vehicle	9.645(29.29)	7.705(36.66)	10.702(26.4)	7.886(35.82)	12.633(22.36)	8.107(34.84)
2.2	With EFE Heater Grid, Pin-Fin Exhaust Manifold, Full-Wrap Stove & recalibrated Choke	10.041(28.13)	7.820(36.12)	10.561(26.75)	7.737(36.51)	12.108(23.33)	7.995(35.33)
2.2.5	Same as 2.2 above with EFE powered externally					12.136(23.28)	7.974(35.43)
2.D.X	Same as 2.2	9.927(28.46)	7.853(35.97)				
2.D.Y	Same as 2.1, but with Pin-Fin Exhaust Manifold and Full-Wrap Stove	9.978(28.31)	7.836(36.05)				
2.3	Retest of modified vehicle (same mods as 2.2 above) after repairs	10.066(28.06)	7.772(36.34)	10.586(26.68)	7.911(35.71)	11.896(23.74)	8.051(35.09)

Note: New EFE heated grid installed prior to 2.D.X, 2.D.Y, and 2.3

Table 20 - Average Fuel Consumption Data for Early Fuel Evaporation Configuration (Vehicle 2)

TEST NO.	CONFIGURATION	AVERAGE FUEL CONSUMPTION Litres/100 km (mi/imperial gal.)					
		25°C (77°F)		0°C (32°F)		-20°C (-4°F)	
		CITY	HWY	CITY	HWY	CITY	HWY
4.1	Base Vehicle	9.000(31.14)	7.283(38.79)			11.873(23.79	7.753(36.44)
4.4.X	Base Vehicle With block heater on 4 hours					10.924(25.86	7.678(36.79)
4.4.Y	Base Vehicle With block heater on 2½ hours					10.741(26.3)	7.506(37.63)
4.4.Z	Base Vehicle With block heater on 1 hour					11.156(25.32)	7.469(37.82)
4.5	With winter front, engine insulation, no bleed thermostat, and under-engine pan	9.075(31.13)	7.143(39.55)			11.212(25.19)	7.371(38.32)
4.7	Similar to 4.5 series with reduced road load power setting	8.974(31.48*)	6.963(40.57*)			10.963(25.77**)	7.078(39.91**)

* At 7.3 H.P.
** At 7.0 H.P.

Note: H.P. for all other tests=7.9 H.P.

Table 21 - Average Fuel Consumption Data for Block Heat Conservation Configuration (Vehicle 4)

TEST NO.	CONFIGURATION	AVERAGE FUEL CONSUMPTION Litres/100 km (mi/imperial gal.)					
		25°C (77°F)		0°C (32°F)		-20°C (-4°F)	
		CITY	HWY	CITY	HWY	CITY	HWY
5.1	Base Vehicle	9.085(31.09)	7.171(39.39)	10.177(27.76)	7.367(38.34)	12.294(22.98)	7.713(36.62)
5.2	High Compression Spark Schedule "A" Chip #1	8.553(33.03)	6.749(41.86)	9.792(28.85)	6.910(40.88)	11.815(23.91)	7.245(38.99)
5.3	High Compression Spark Schedule "B" Chip #12	8.431(33.51)	6.692(42.21)	9.542(29.60)	6.810(41.48)		
5.4	High Compression Spark Schedule "C" Chip #2	8.559(33.00)	6.770(41.73)	9.624(29.35)	6.998(40.37)	11.446(24.68)	7.251(38.96)

Table 22 - Average Fuel Consumption Data for High Compression Configuration (Vehicle 5)

		SID			
TEST NUMBER	CONFIGURATION	COLD START	COLD IDLE	COLD DRIVE	WARM IDLE
2.1.1-1	Base Vehicle	3*	7	7	7
2.1.1-2		8	8	8	8
2.1.1-3		8	7	8	7
2.2.1-1	w/ EFE Heater Grid, Pin-Fin Exhaust manifold, full-wrap stove and recalibrated choke	7	7	8	8
2.2.1-2		7	7	7	7
2.2.1-3		8	7	8	7
4.1.1-1	Base Vehicle	5*	7	6	8
4.1.1-2		7*	7	8	7
4.1.1-3		7	6	7	8
4.3.1-1	Base Vehicle with 2½-Hr. Block Heater Preheat	9	7	8	7
4.3.1-2		9	7	8	7
4.4.1-1	Base Vehicle with 1-Hr. Block Heater Preheat	9	8	8	7
4.4.1-2		9	7	7	7
4.5.1-1	w/winter front, engine insulation, no-bleed thermostat and under-engine pan	9	9	8	7
4.5.1-2		9	6*	8	7
4.5.1-3		5	7	8	7
5.1.1-1	Base Vehicle	7	7	8	7
5.1.1-2		9	7	7	7
5.1.1-3		-	6	7	8
5.2.1-1	w/ 9.5:1 Compression ratio; and spark schedule "A"	9	8	8	8
5.2.1-2			8	7	7
5.2.1-3		7	8	7	7
5.3.1-1	w/9.5:1 Compression ratio; spark schedule "B"	9	6*	8	8
5.3.1-2		9	5*	8	7
5.3.1-3		9	8	8	7

* Indicates Engine Die-Out

+ P.C.D. = Partial Cool Down

RATINGS							WEATHER CONDITIONS		
ARM DRIVE	HOT START	HOT IDLE	HOT DRIVE	P.C.D. + START	P.C.D. + IDLE	P.C.D. + DRIVE	OVERNIGHT LOW TEMPERATURE (°C)	TEST TEMPERATURE (°C)	% RELATIVE HUMIDITY
	8	7	8	9	7	7	-8	-8	79
	8	8	9	8	8	7	-11	4	70
	6	7	8	5	7	8	-4	-3	100
	9	8	8	9	9	9	-20	-16	65
	9	8	8	9	8	8	-25	-23	70
	8	8	8	9	8	8	-24	-14	92
	9	7	8	9	8	9	-14	0	69
	9	6	8	9	7	8	-	-8	79
	8	7	8	8	6	8	-11	-1	80
	9	7	8	9	7	8	-20	-14	78
	9	7	8	9	7	8	-13	-4	93
	9	8	7	9	8	8	-20	-21	64
	0	7	8	8	7	8	-31	-27	69
	9	7	8	9	7	8	-20	-2	63
	9	7	8	9	7	8	0	7	100
	8	7	8	9	7	8	-15	-14	46
	9	8	9	4	7	8	-14	0	69
	9	6	7	9	7	8	-	-8	79
	7	7	7	8	7	8	-11	0	80
	8	8	8	8	7	8	-11	-10	52
	6	7	7	8	7	8	-18	-13	62
	9	7	8	7	7	8	-20	-19	65
	9	7	8	9	8	8	2	6	100
	9	7	8	9	7	8	1	1	100
	9	7	8	9	7	8	0	1	93

e Section 3.1.4)

TABLE 23 - SUMMARY OF DRIVEABILITY SID RATINGS

VEHICLE NO	AVERAGE % INCREASE IN FUEL CONSUMPTION					
	CITY			HIGHWAY		
	+25°C	0°C	-20°C	+25°C	0°C	-20°C
2	Baseline	11.0	31.0	Baseline	2.5	5.4
4	Baseline	No Tests	31.9	Baseline	No Tests	6.5
5	Baseline	11.9	35.2	Baseline	2.6	7.4
Average All Vehicles	Baseline	11.4	32.7	Baseline	2.5	6.4

TABLE 24 - INCREASE IN FUEL CONSUMPTION WITH TEMPERATURE FOR BASE VEHICLES

TEST SERIES NUMBER	CONFIGURATION	AVERAGE % IMPROVEMENT IN FUEL CONSUMPTION					
		CITY			HIGHWAY		
		+25°C	0°C	-20°C	+25°C	0°C	-20°C
2.1	Base Car	←	Baseline	→	←	Baseline	→
2.2	With EFE Heater Grid, Pin-Fin Exhaust Manifold, Full-Wrap Stove, and Recalibrated Choke	-4.1	+1.3	+4.2	-1.5	+1.9	+1.4
2.3	Retest of Modified Car (same mods as Test Series 2.2) after repairs	-4.4	+1.1	+5.8	-0.9	-0.3	+0.7

TABLE 25 - IMPROVEMENT IN FUEL CONSUMPTION OVER BASELINE FOR EARLY FUEL EVAPORATION VEHICLE

TEST SERIES NUMBER	CALIBRATION	AVERAGE % IMPROVEMENT IN FUEL CONSUMPTION											
		+25°C				0°C				-20°C			
		Bag 1	Bag 2	Bag 3	City Cycle	Bag 1	Bag 2	Bag 3	City Cycle	Bag 1	Bag 2	Bag 3	City Cycle
2.1	Base Car	◄— B	A S E	L I N	E ——►	◄— B	A S E	L I N	E ——►	◄— B	A S E	L I N	E ——►
2.2	With EFE Heater Grid, Pin-Fin Exhaust Manifold, Full-Wrap Stove and recalibrated Choke	-8.3	-3.6	-1.5	-4.1	+11.6	-3.7	-0.7	+1.3	+14.3	-1.4	+0.2	+4.2
2.3	Retest of Modified Car (same mods. as above) after repairs	-5.8	-4.9	-2.4	-4.4	+13.1	-3.8	-3.2	+1.1	+17.5	-0.4	+0.3	+5.8

TABLE 26 - BREAKDOWN OF IMPROVEMENT IN CITY CYCLE FUEL CONSUMPTION OVER BASELINE FOR EARLY FUEL EVAPORATION VEHICLE

TEST SERIES NUMBER	CONFIGURATION	AVERAGE CHOKE-ON TIME (SEC)		
		$+25^{\circ}C$	$0^{\circ}C$	$-20^{\circ}C$
2.1	Base Car	Not Available	577	805
2.2	With EFE Heater Grid, Pin-Fin Exhaust Manifold, Full-Wrap Stove and recalibrated Choke	261	287	430
2.3	Retest of modified car (same mods as above) after repairs	259	Not Available	Not Available

Notes:- Choke-on time defined as time from engine start to time when choke is in full open position.

- Data shown for each case is average of (2) runs.

TABLE 27 - CHOKE-ON TIMES FOR EARLY FUEL EVAPORATION VEHICLE

TEST SERIES NUMBER	CONFIGURATION	AVERAGE START TIMES (SEC)		
		+25°C	0°C	-20°C
2.1	Base Car	Less Than 1	Less Than 1	4
2.2	With EFE Heater Grid Pin-Fin Exhaust Manifold, Full-Wrap Stove and recalibrated Choke	Less Than 1	1	4
2.3	Retest of modified car (same mods as above) after repairs	1	N/A	3

Notes: -Data shown for each case is average of (2) runs minimum (see Figure 10 for illustration of start time)

TABLE 28 - START TIMES FOR EARLY FUEL EVAPORATION VEHICLE

TEST NO.	CONFIGURATION	SID RATINGS			WEATHER CONDITIONS		
		Cold Start	Cold Idle	Cold Drive	Overnight Low Temp. (°C)	Test Temp. (°C)	% Relative Humidity
2.1.1-1	Base Car	3*	7	7	-8	-8	79
-2		8	8	8	-11	4	70
-3		8	7	8	-4	-3	100
2.2.1-1	With EFE Heater, Grid Pin-Fin Exhaust Manifold, Full-Wrap Stove, and recalibrated Choke	7	7	8	-20	-16	65
-2		7	7	7	-35	-23	70
-3		8	7	8	-24	-14	92

* Indicates Engine Die-out

TABLE 29 - DRIVEABILITY RATINGS FOR SELECTED PORTIONS OF DRIVEABILITY TESTS ON EARLY FUEL EVAPORATION VEHICLE

TEST SERIES NUMBER	CONFIGURATION	AVERAGE % IMPROVEMENT IN FUEL CONSUMPTION					
		CITY			HIGHWAY		
		+25°C	0°C	-20°C	+25°C	0°C	-20°C
4.1	Base Car	◀	Baseline	▶	◀	Baseline	▶
4.4.X	Base car with 4-hour Block Heater Preheat			+8.0			+1.0
4.4.Y	Base car with 2½-hour Block Heater Preheat			+9.5			+3.2
4.4.Z	Base car with 1-hour Block Heater Preheat			+6.0			+3.7
4.5	With Winter front, engine insulation, no bleed thermostat, and under-engine pan	-0.9		+5.6	+1.9		+4.9
4.7	Same mods as 4.5 with lower road load H.P. settings*	+0.3		+7.7	+4.4		+8.7

* 25°C tests run at 7.3 H.P.
-20°C tests run at 7.0 H.P.
All other tests in other test series were run at 7.9 H.P.

TABLE 30 - IMPROVEMENT IN FUEL CONSUMPTION OVER BASELINE FOR BLOCK HEAT CONSERVATION VEHICLE

TEST SERIES NUMBER	CONFIGURATION	AVERAGE % IMPROVEMENT IN FUEL CONSUMPTION											
		+25°C				0°C				-20°C			
		Bag 1	Bag 2	Bag 3	City Cycle	Bag 1	Bag 2	Bag 3	City Cycle	Bag 1	Bag 2	Bag 3	City Cycle
4.1	Base Car	◄ Baseline ►				◄ Baseline ►				◄ Baseline ►			
4.4.X	Base Car with 4-hr Block Heater Pre-Heat									+22.8	-0.4	+2.1	+8.0
4.4.Y	Base Car with 2½ Hr. Block Heater Preheat									+23.1	+2.5	+2.8	+9.5
4.4.Z	Base Car with 1-Hr. Block Heater Preheat									+13.7	-2.1	+3.4	+6.0
4.5	With winter front, engine insulation, No-bleed thermostat and under-engine pan	-3.6	-1.0	+1.6	-0.8					+5.8	+4.1	+7.8	+5.6
4.7	Same mods. as 4.5 with lower road load H.P. settings *	-2.1	+0.3	+1.7	+0.3					+10.7	+3.9	+10.0	+7.7

* 25°C tests run at 7.3 H.P.
-20°C tests run at 7.0 H.P.
All other tests in other test series were run at 7.9 H.P.

TABLE 31 - BREAKDOWN OF IMPROVEMENT IN CITY CYCLE FUEL CONSUMPTION OVER BASELINE FOR BLOCK HEAT CONSERVATION VEHICLE

TEST SERIES NUMBER	CONFIGURATION	AVERAGE CHOKE-ON TIME (SEC)		
		$+25^{\circ}$C	0°C	-20°C
4.1	Base Car	N/A	No Tests	657
4.4.X	Base car with 4-hour block heater preheat	No Tests	No Tests	473
4.4.Y	Base car with 2½-hour block heater preheat	No Tests	No Tests	506
4.4.Z	Base car with 1-hour block heater preheat	No Tests	No Tests	617
4.5	With winter front engine insulation, no-bleed thermostat, and under-engine pan	324	No Tests	582
4.7	Same mods. as 4.5 with lower road load H.P. setting*	197	No Tests	612

Notes: - Choke-on time defined as time from engine start to time when choke is in full open position
- Data shown for each case is an average of at least (2) runs

* 25°C tests run at 7.3 H.P.
-20°C tests run at 7.0 H.P.
All other tests in other test series were run at 7.9 H.P.

TABLE 32 - CHOKE-ON TIMES FOR ENGINE BLOCK HEAT CONSERVATION VEHICLE

TEST SERIES NUMBER	CONFIGURATION	AVERAGE START TIMES (SEC)		
		25°C	0°C	-20°C
4.1	Base Car	Less Than 1	No Tests	6
4.4.X	Base car with 4-hour block heater preheat	No Tests	No Tests	1
4.4.Y	Base car with 2½-hour block heater preheat	No Tests	No Tests	1
4.4.Z	Base car with 1-hour block heater preheat	No Tests	No Tests	1
4.5	With winter front, engine insulation, no bleed thermostat, and under-engine pan	1	No Tests	14
4.7	Same mods. as 4.5 with lower road load H.P. setting*	1	No Tests	10

Notes: - Data shown for each case is an average of at least (2) runs

* 25°C tests run at 7.3 H.P.
-20°C tests run at 7.0 H.P.
All other tests in other test series were run at 7.9 H.P.

TABLE 33 - START TIMES FOR ENGINE BLOCK HEAT CONSERVATION VEHICLE

TEST NUMBER	CONFIGURATION	SID RATINGS											WEATHER CONDITIONS		
		COLD START	COLD IDLE	COLD DRIVE	WARM IDLE	WARM DRIVE	HOT START	HOT IDLE	HOT DRIVE	P.C.D.+ START	P.C.D.+ IDLE	P.C.D.+ DRIVE	OVERNIGHT LOW TEMP. (°C)	TEST TEMP. (°C)	% RELATIVE HUMIDITY
4.1.1-1	Base Car	5*	7	6	8	9	9	7	8	9	8	9	-14	0	69
-2		7*	7	8	7	8	9	6	8	9	7	8	N/A	-8	79
-3		7	6	7	8	9	8	7	8	8	6	8	-11	-1	80
4.3.1-1	Base Car with 2½-Hr. Block Heater Preheat	9	7	8	7	9	9	7	8	9	7	8	-20	-14	78
-2		9	7	8	7	9	9	7	8	8	7	8	-13	-4	93
4.4.1-1	Base car with 1-Hr. Block Heater Preheat	9	8	8	7	8	9	8	7	9	8	8	-20	-21	64
-2		9	7	7	7	8	0	7	8	8	7	8	-31	-27	69

* Indicates Engine Die-out

+ P.C.D. = Partial Cooldown (See Section 3.1.4)

TABLE 34 - DRIVEABILITY RATINGS FOR SELECTED PORTIONS OF DRIVEABILITY TESTS ON BLOCK HEAT CONSERVATION VEHICLE IN BASE CONFIGURATION USING BLOCK HEATER

TEST NUMBER	CONFIGURATION	SID RATINGS											WEATHER CONDITIONS		
		COLD START	COLD IDLE	COLD DRIVE	WARM IDLE	WARM DRIVE	HOT START	HOT IDLE	HOT DRIVE	P.C.D.+ START	P.C.D.+ IDLE	P.C.D.+ DRIVE	OVERNIGHT LOW TEMP. (°C)	TEST TEMP. (°C)	% RELATIVE HUMIDITY
4.1.1-1	Base Car	5*	7	6	8	9	9	7	8	9	8	9	-14	0	69
-2		7*	7	8	7	8	9	6	8	9	7	8	N/A	-8	79
-3		7	6	7	8	9	8	7	8	8	6	8	-11	-1	80
4.5.1-1	With Winter Front, Engine Insulation, No-Bleed Thermostat, and Under-Engine Pan	9	7	8	7	9	9	7	8	9	7	8	-20	-2	63
-2		9	8	8	7	9	9	7	8	9	7	8	0	7	100
-3		5	7	8	7	9	8	7	8	9	7	8	-15	-14	46

+ P.C.D. = Partial Cooldown (See Section 3.1.4)

* Indicates Engine Die-out

TABLE 35 - DRIVEABILITY RATINGS FOR SELECTED PORTIONS OF DRIVEABILITY TEST ON BLOCK HEAT CONSERVATION VEHICLE WITH WINTER FRONT ENGINE INSULATION, NO-BLEED THERMOSTAT, AND UNDER-ENGINE PAN (NO BLOCK HEATER)

PARAMETER	TIME (MINUTES) TO REACH 90% OF FINAL VALUE DURING SOAK AT -20°C (-4°F)	
	BASE	MODIFIED
Transmission Oil	570	690
Left Hood	300	-
Stove Output	390	660
Carb-Air Inlet	480	660
Crankcase Oil	570	690
Frost Plug	-	690
Thermostat	630	690

TABLE 36 - STABILIZATION TIMES FOR VARIOUS ENGINE-RELATED PARAMETERS DURING COOLDOWN RUNS ON THE BASE AND MODIFIED CONFIGURATIONS OF THE BLOCK HEAT CONSERVATION VEHICLE

PARAMETER	TEMPERATURE AFTER 10 HOURS OF SOAKING AT -20°C (-4°F) FOR ENGINE BLOCK HEAT CONSERVATION VEHICLE °C (°F)	
	Base	Modified
Transmission Oil	-17.0 (1.4)	-10.4 (13.3)
Left Hood	-19.4 (-2.9)	-
Stove Output	-18.2 (-.8)	-12.7 (9.1)
Carb-Air Inlet	-18.4 (-1.1)	-11.9 (10.6)
Crankcase Oil	-16.8 (-1.0)	-10.2 (13.6)
Frost Plug	-	-10.6 (12.9)
Thermostat	-18.7 (-1.7)	-10.9 (12.4)

TABLE 37 - TEMPERATURES OF VARIOUS PARAMETERS FOR BASE AND MODIFIED CONFIGURATIONS OF ENGINE BLOCK HEAT CONSERVATION VEHICLE AFTER 10 HOURS OF SOAKING AT -20°C (-4°F)

PARAMETER	TEMPERATURE AFTER 8 HOURS OF PREHEAT FROM APPLICATION OF BLOCK HEATER WHILE SOAKING AT -20°C (-4°F) °C (°F)	
	Base	Modified
Transmission Oil	-11.9 (10.6)	-4.9 (23.2)
Left Hood	- 5.9 (21.4)	-
Stove Output	- 3.4 (25.9)	0.1 (31.8)
Car-Air Inlet	6.4 (43.5)	9.0 (48.2)
Crankcase Oil	- 4.9 (23.2)	4.2 (39.6)
Frost Plug	-	0.0 (32)
Thermostat	35.3 (95.5)	42.7 (108.9)

TABLE 38 - TEMPERATURES OF VARIOUS PARAMETERS FOR BASE AND MODIFIED CONFIGURATIONS OF ENGINE BLOCK HEAT CONSERVATION VEHICLE AFTER 8 HOURS OF PREHEAT FROM BLOCK HEATER WHILE SOAKING AT -20°C (-4°F)

TEST SERIES NUMBER	CONFIGURATION	AVERAGE % IMPROVEMENT IN FUEL CONSUMPTION					
		CITY			HIGHWAY		
		+25°C	0°C	-20°C	+25°C	0°C	-20°C
5.1	Base Car	◄—	Baseline	—►	◄—	Baseline	—►
5.2	w/9.5:1 CR Calibration 'A' (Prom #1)	+5.9	+3.8	+3.9	+5.9	+6.2	+6.1
5.3	w/9.5:1 CR Calibration 'B' Prom #12)	+7.2	+6.2		+6.7	+7.6	
5.4	w/9.5:1 CR Calibration 'C' (Prom # 2)						

TABLE 39 - IMPROVEMENT IN FUEL CONSUMPTION OVER BASELINE FOR HIGH COMPRESSION VEHICLE

TEST SERIES NUMBER	CONFIGURATION	AVERAGE % IMPROVEMENT IN FUEL CONSUMPTION											
		+25°C				0°C				-20°C			
		Bag 1	Bag 2	Bag 3	City Cycle	Bag 1	Bag 2	Bag 3	City Cycle	Bag 1	Bag 2	Bag 3	City Cycle
5.1	Base Car	BAS	ELI	NE	→	BAS	ELI	NE	→	BAS	ELI	NE	→
5.2	w/9.5:1 CR Calibration 'A' (Prom #1)	+6.5	+5.2	+6.7	+5.9	+6.9	+5.2	-2.3	+3.8	+2.1	+5.4	+3.2	+3.8
5.3	Calibration 'B' (Prom #12)	+9.0	+6.3	+7.4	+7.3	+4.6	+7.3	+6.5	+6.3				
5.4	Calibration 'C' (Prom #2)	+7.9	+5.0	+5.4	+5.9	+10.0	+3.1	+4.8	+5.4	+10.8	+4.5	+5.3	+6.9

TABLE 40 - BREAKDOWN OF IMPROVEMENT IN CITY CYCLE FUEL CONSUMPTION OVER BASELINE FOR HIGH COMPRESSION VEHICLE

TEST NO.	CONFIGURATION	SID RATINGS				WEATHER CONDITIONS		
		Cold Start	Cold Idle	Cold Drive	Warmed-up Performance	Overnight Low Temp. (°C)	Test Temp. (-°C)	% Relative Humidity
5.1.1-1	Base Car	7	7	8	9	-14	0	69
-2		9	7	7	8	N/A	-8	79
-3			6	7	8	-11	0	80
5.2.1-1	w/9.5:1 CR Calibration 'A'	9	8	8	9	-11	-10	52
-2		8*	8	7	9	-13	-13	61
-3		7	8	7	8	-20	-19	65
5.3.1-1	Calibration 'B'	4*	7	8	8	2	6	100
-2		2*	7	8	8	1	1	100
-3		9	8	8	8	0	1	93

* Indicates Engine Die-out

TABLE 41 - DRIVEABILITY RATINGS FOR SELECTED PORTIONS OF DRIVEABILITY TESTS ON HIGH COMPRESSION VEHICLE

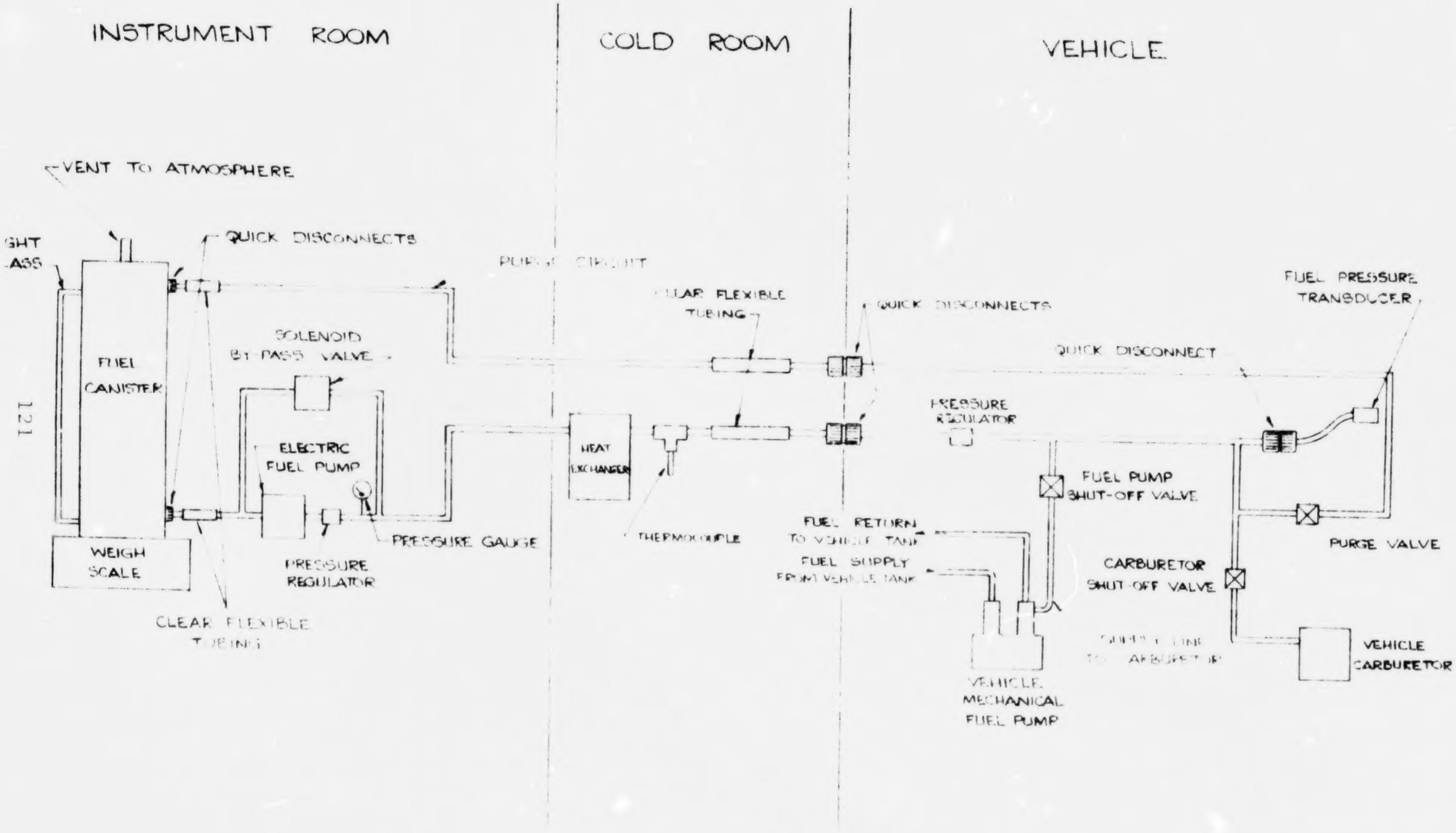

INSTRUMENT ROOM
COLD ROOM
VEHICLE
VENT TO ATMOSPHERE
GHT
ASS
QUICK DISCONNECTS
PURGE CIRCUIT
FUEL CANISTER
SOLENOID BY-PASS VALVE
ELECTRIC FUEL PUMP
PRESSURE GAUGE
PRESSURE REGULATOR
WEIGH SCALE
CLEAR FLEXIBLE TUBING
CLEAR FLEXIBLE TUBING
HEAT EXCHANGER
THERMOCOUPLE
QUICK DISCONNECTS
QUICK DISCONNECT
PRESSURE REGULATOR
FUEL PRESSURE TRANSDUCER
FUEL PUMP SHUT-OFF VALVE
FUEL RETURN TO VEHICLE TANK
FUEL SUPPLY FROM VEHICLE TANK
PURGE VALVE
CARBURETOR SHUT-OFF VALVE
SUPPLY LINE TO CARBURETOR
VEHICLE CARBURETOR
VEHICLE MECHANICAL FUEL PUMP

Figure 1 - Gravimetric Fuel Consumption System

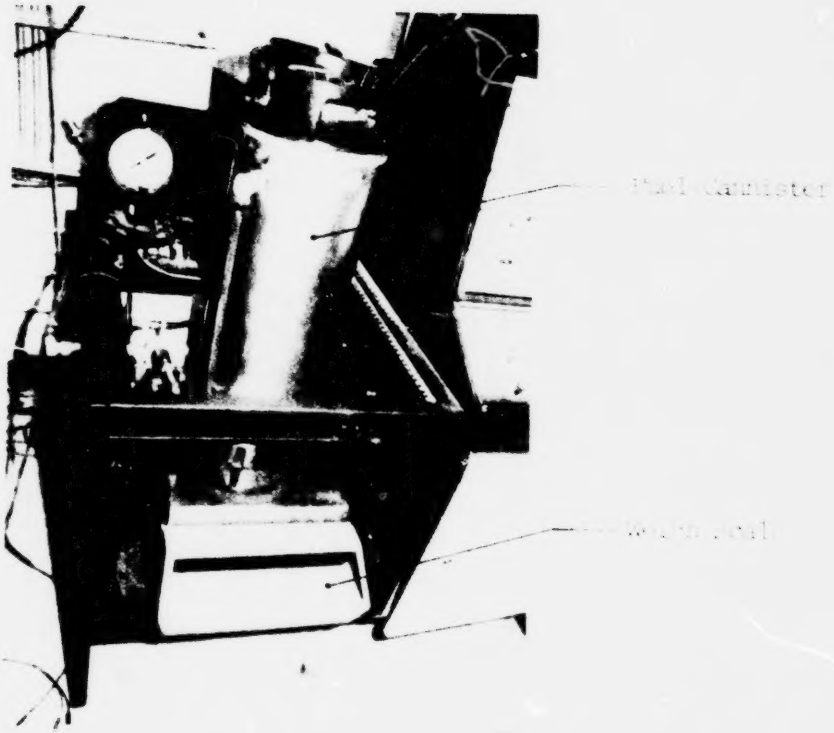

Fuel Cannister
Weigh Scale

Figure 2 - Fuel Cannister and Weigh Scale

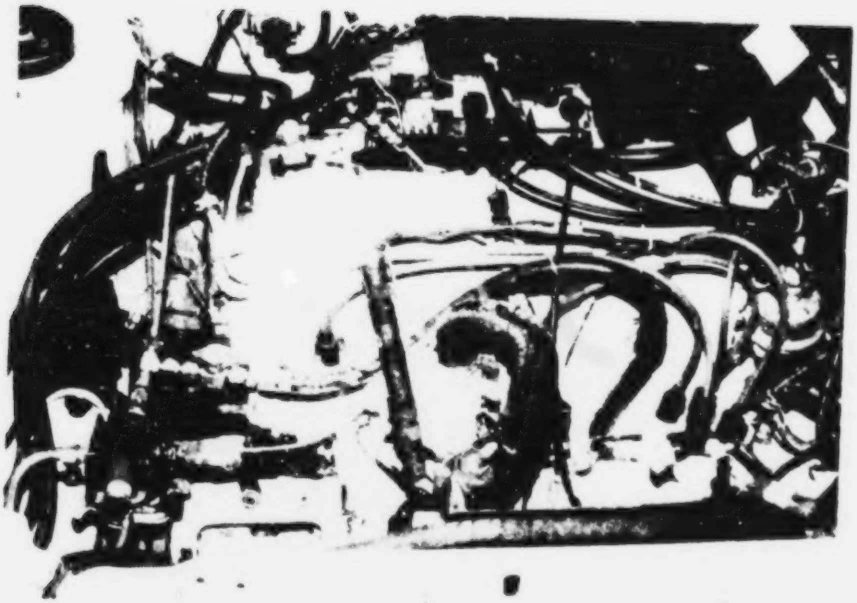


Figure 3 - Vehicle Underhood - Fuel Supply System

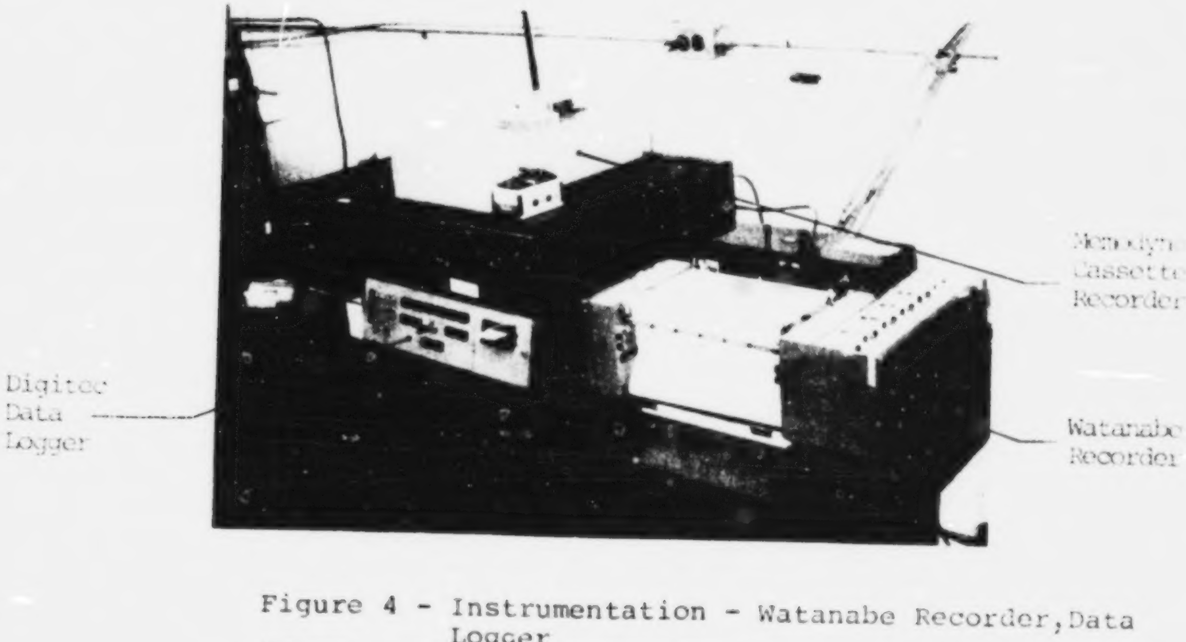

Memodyne
Cassette
Recorder
Digitec
Data
Logger
Watanabe
Recorder

Figure 4 - Instrumentation - Watanabe Recorder, Data Logger

Figure 5 - Instrumentation - Exhaust Gas Analyser

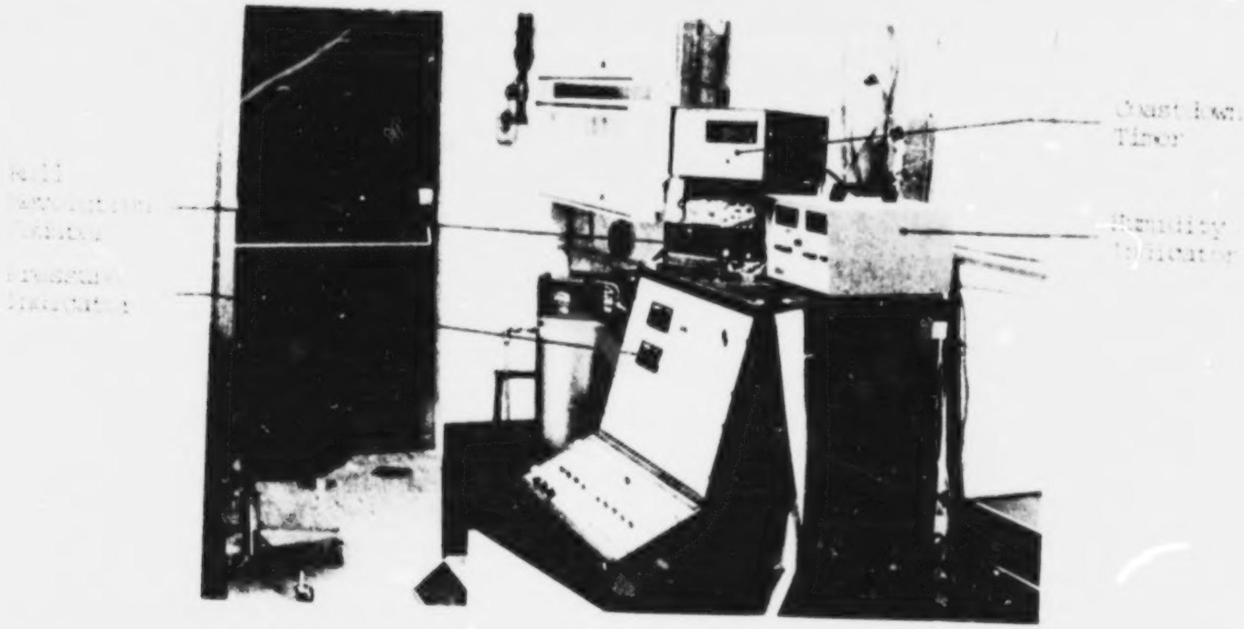

Coastdown Timer
Roll Revolution Counter
Humidity Indicator
Pressure Indicators

Figure 6 - Instrumentation - Roll Revolution Counter, Coastdown Timer, Humidity Indicator and Pressure Indicators

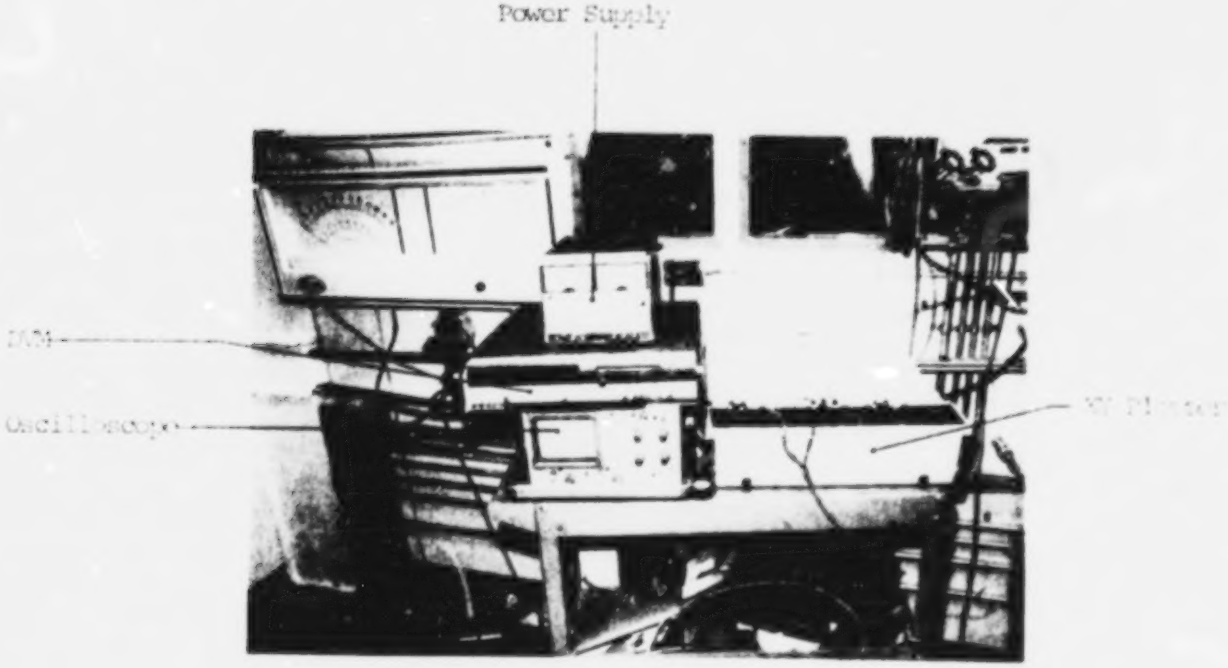
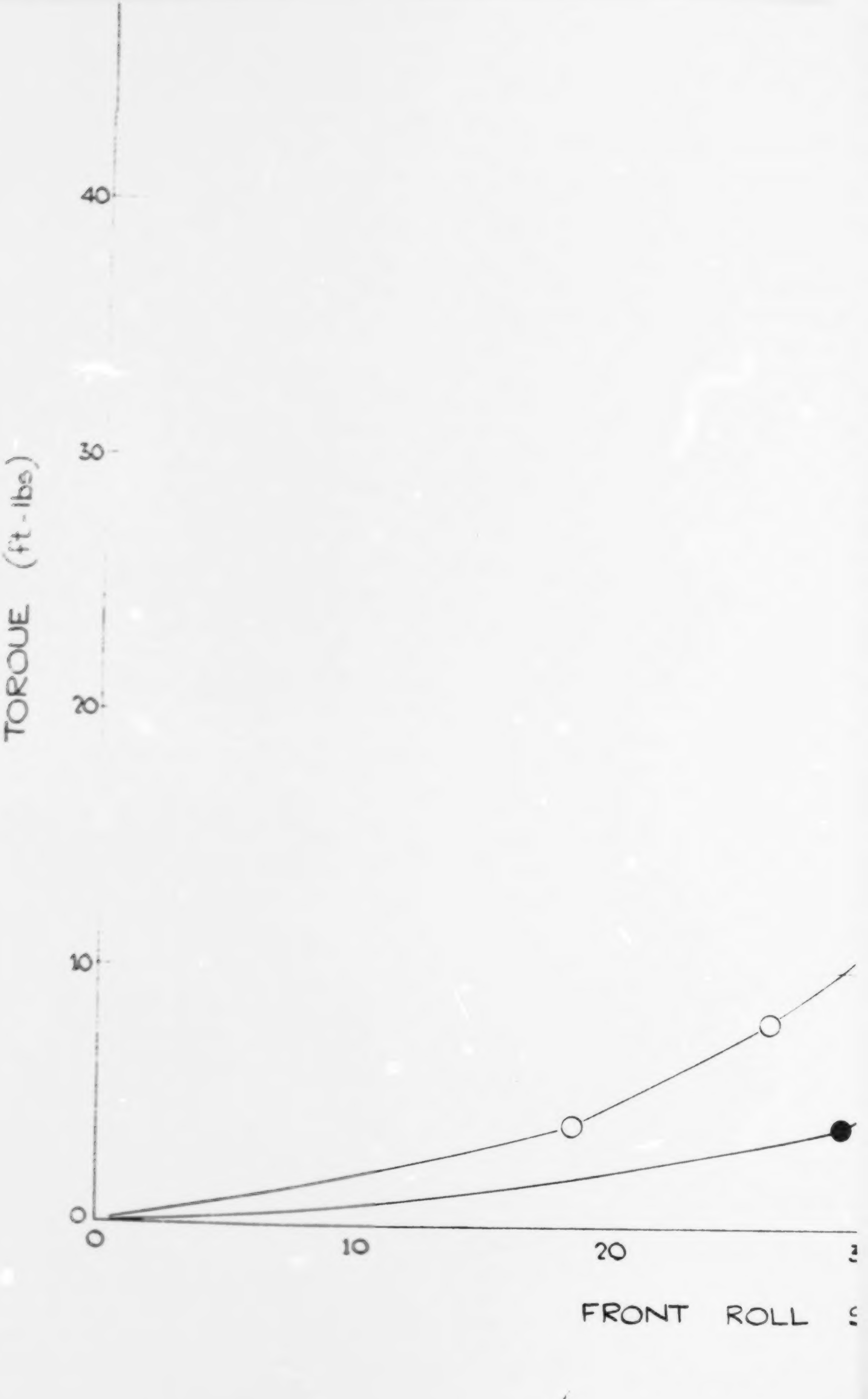

Power Supply
DVM
Oscilloscope
XY Plotter

Figure 7 - Calibration Instrumentation; DVM, Power Supply, XY Plotter, Oscillograph



TORQUE (ft-lbs)
40
30
20
10
0
0
10
20
FRONT ROLL

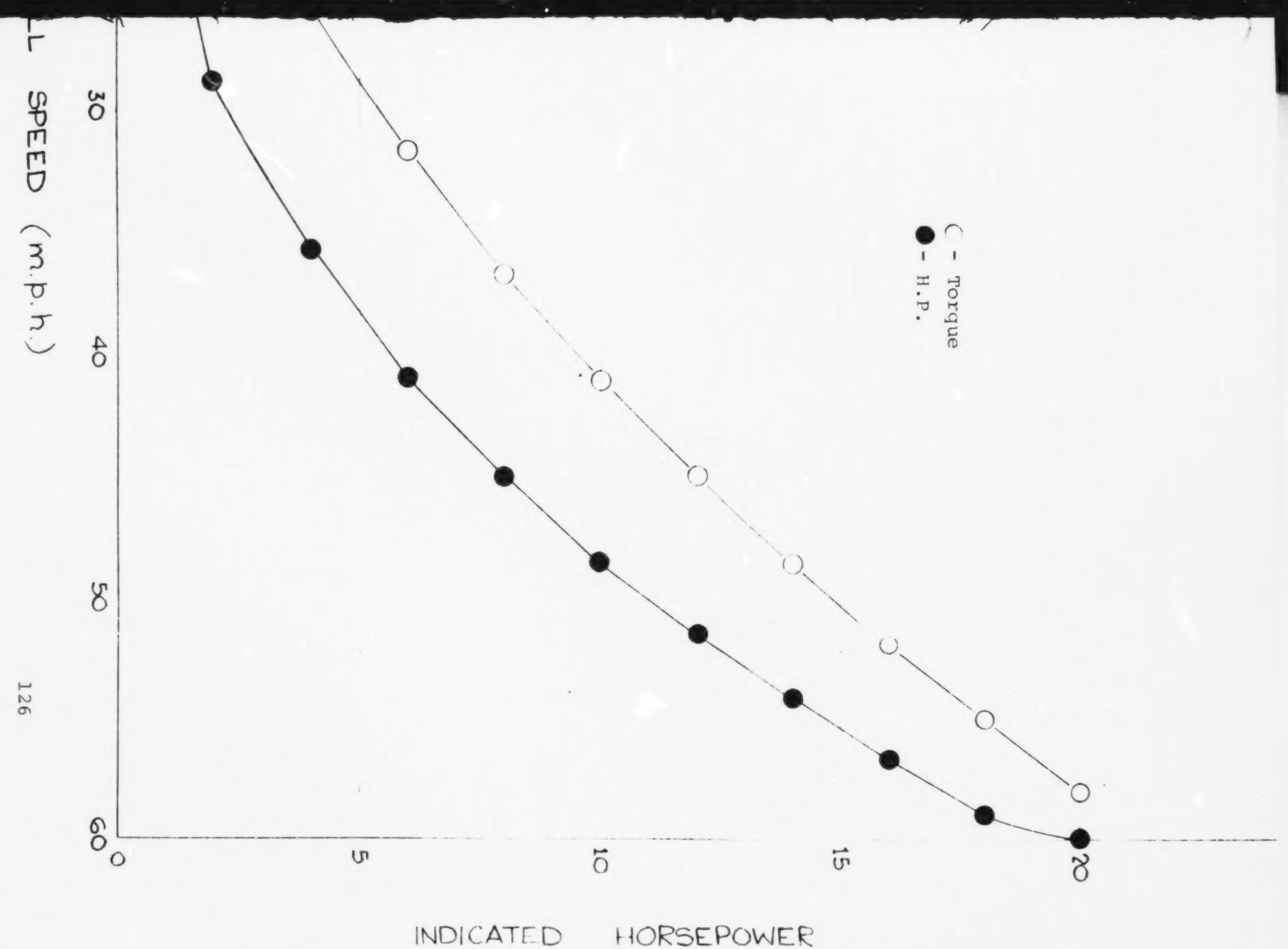


Figure 8 - Theoretical Torque/Horsepower Versus Front Roll Speed Characteristics For Clayton CTE 50 Dynamometer

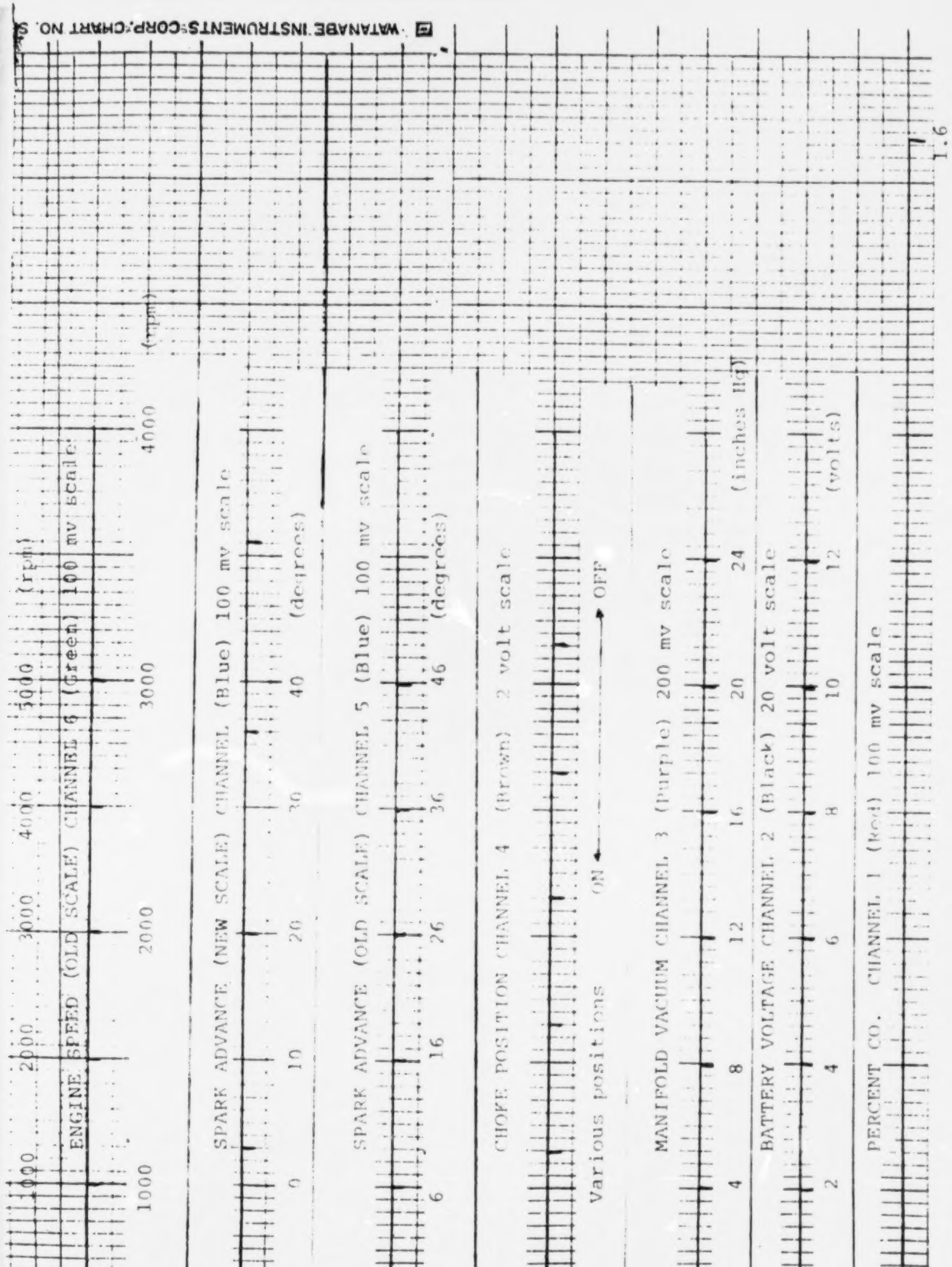


Figure 9- Scaling on Watanabe Recorder

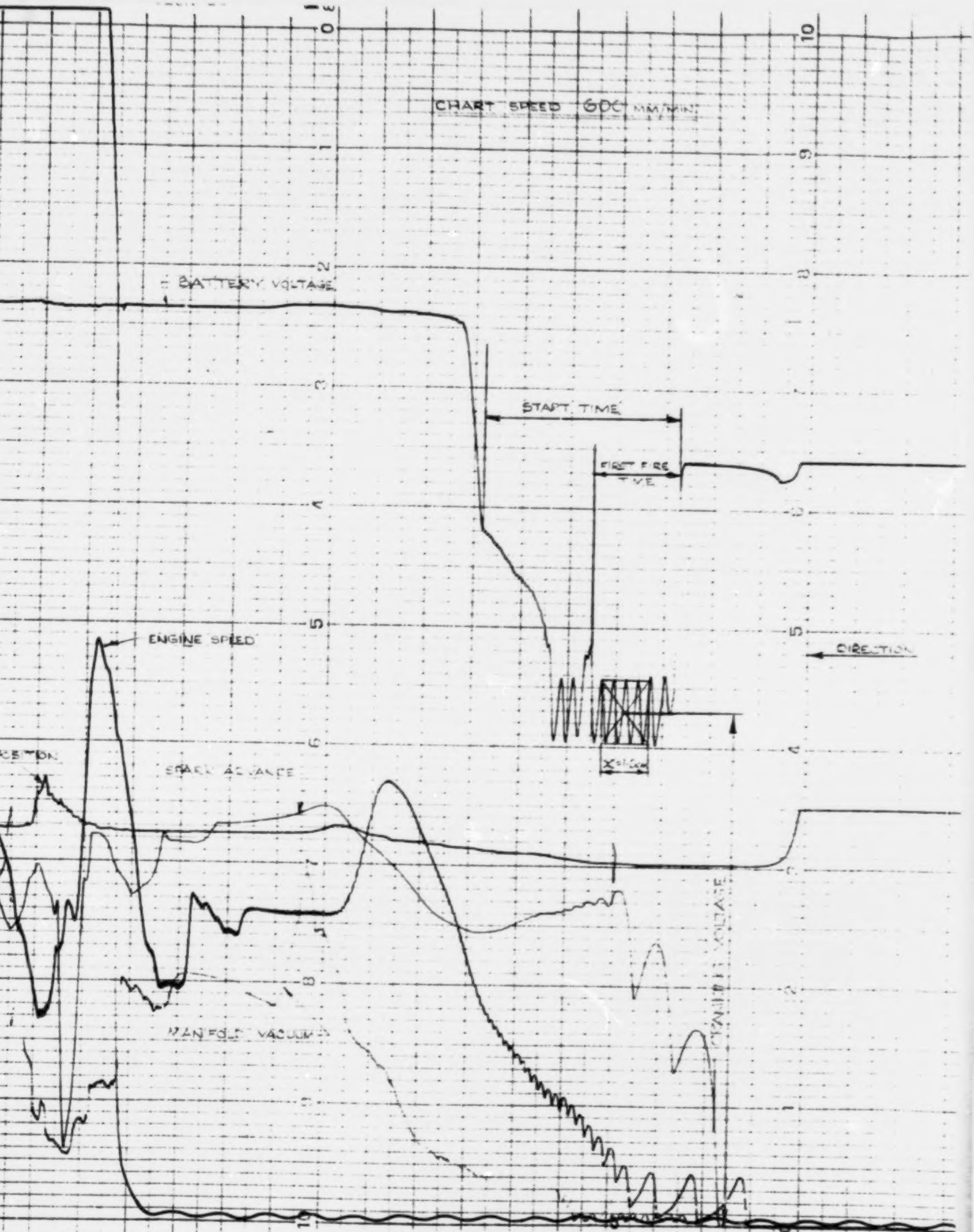


Fig. 10 - Startup Portion of Analog Recorder Output

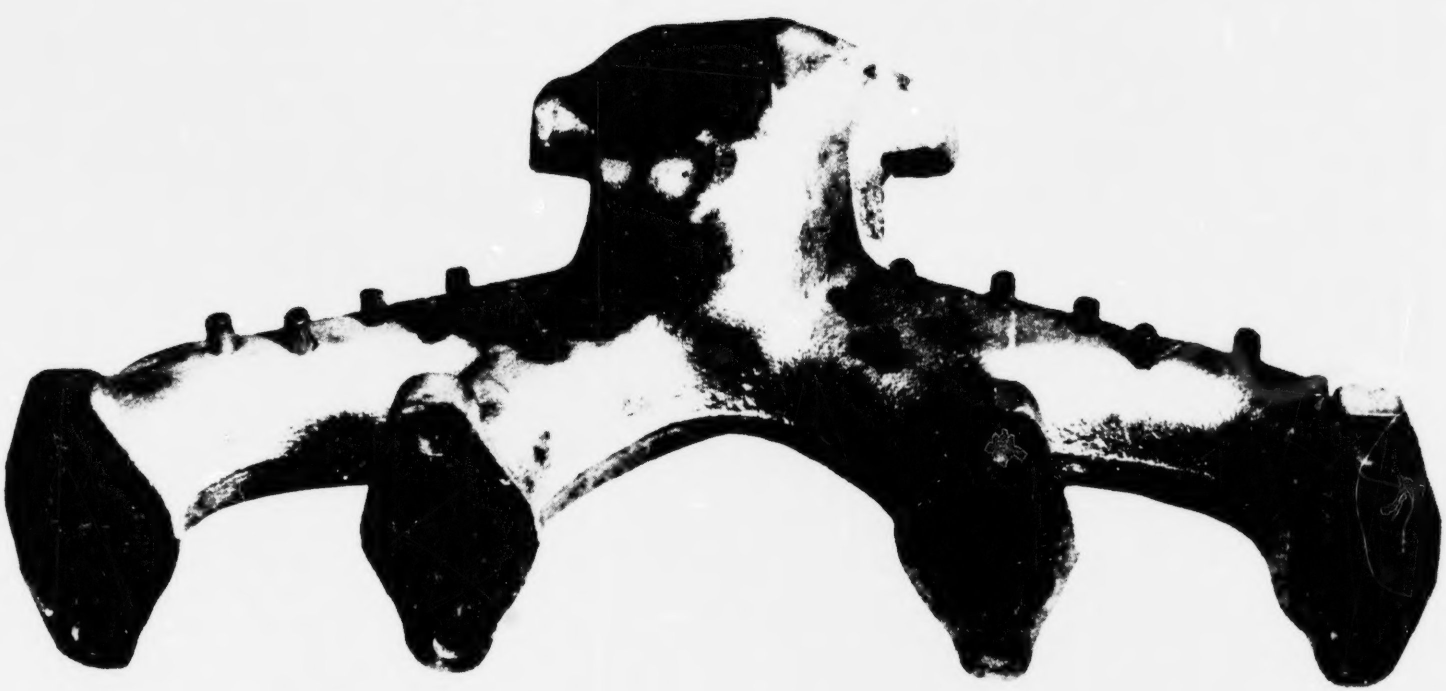


Figure 11 - Pin Fin Exhaust Manifold
I.F.R. Configuration

CHRYSLER CORPORATION	
Pin - Fin Exhaust Manifold	

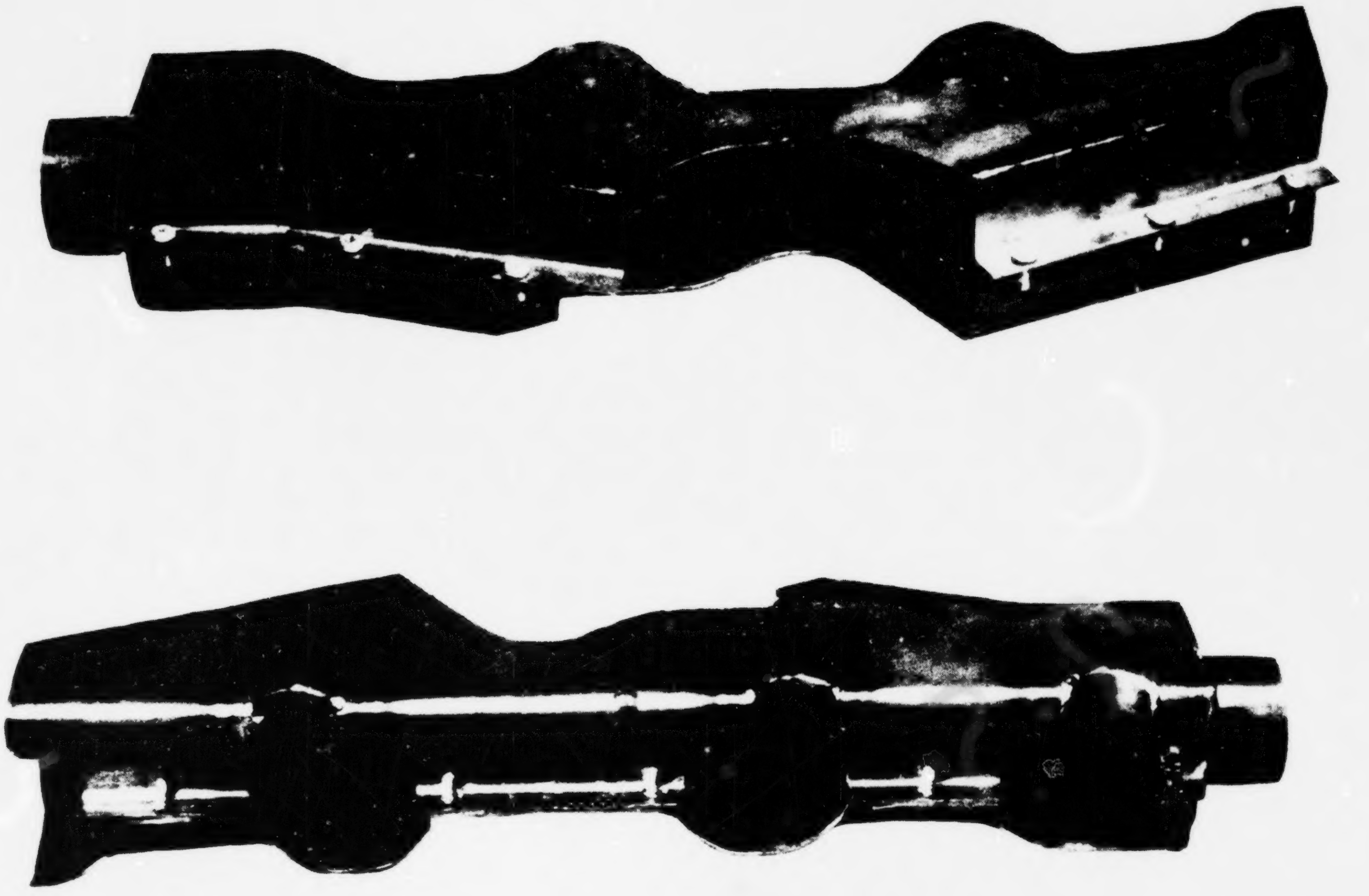


Figure 12 - Full-Wrap Heat Stove
E.F.E. Configuration

CHRYSLER
CORPORATION

[illegible]

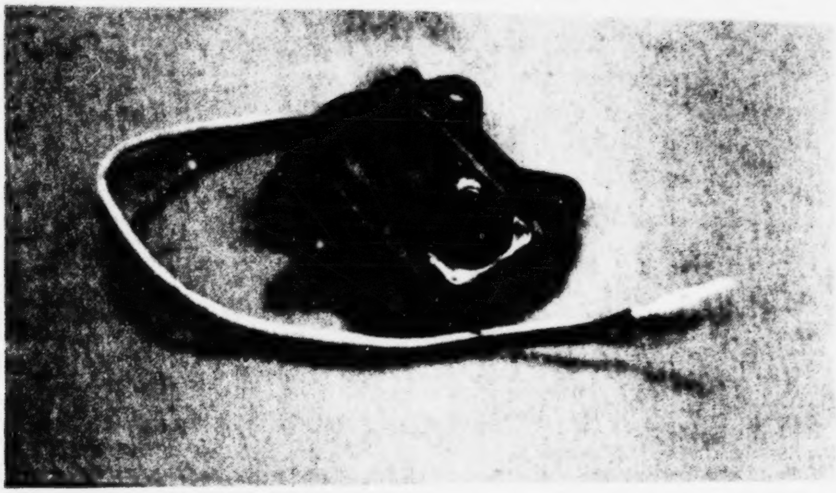


Figure 13 - Heater Grid - E.F.E. Configuration

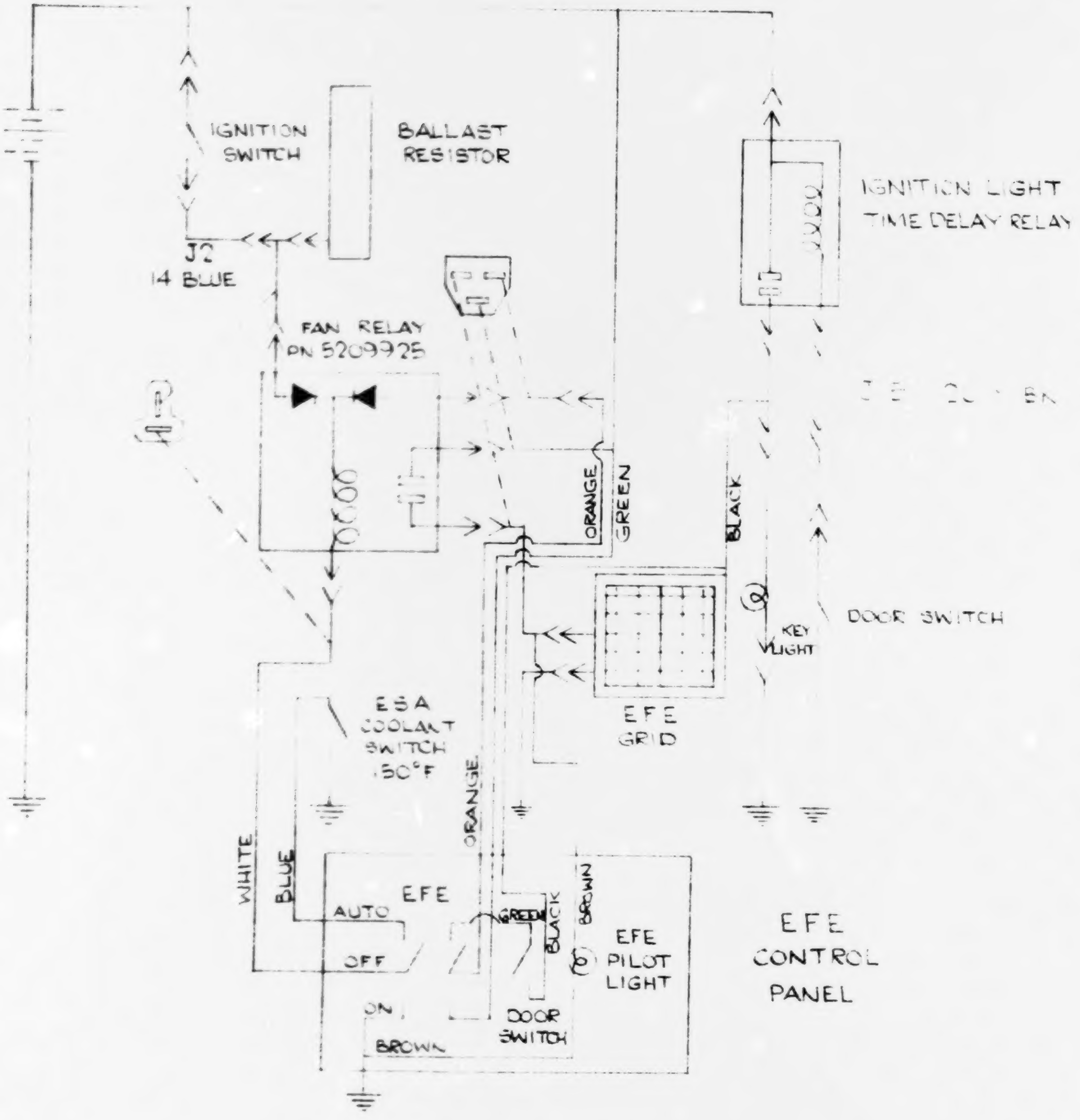

IGNITION SWITCH
BALLAST RESISTOR
IGNITION LIGHT TIME DELAY RELAY
J2
14 BLUE
FAN RELAY
PN 5209925
J B 20 BK
ORANGE
GREEN
BLACK
KEY LIGHT
DOOR SWITCH
EFE GRID
ESA COOLANT SWITCH 150°F
WHITE
BLUE
ORANGE
BROWN
EFE
AUTO
OFF
ON
GREEN
BLACK
BROWN
EFE PILOT LIGHT
DOOR SWITCH
EFE CONTROL PANEL

Figure 14 - Schematic of E.F.E. Electrical Circuit

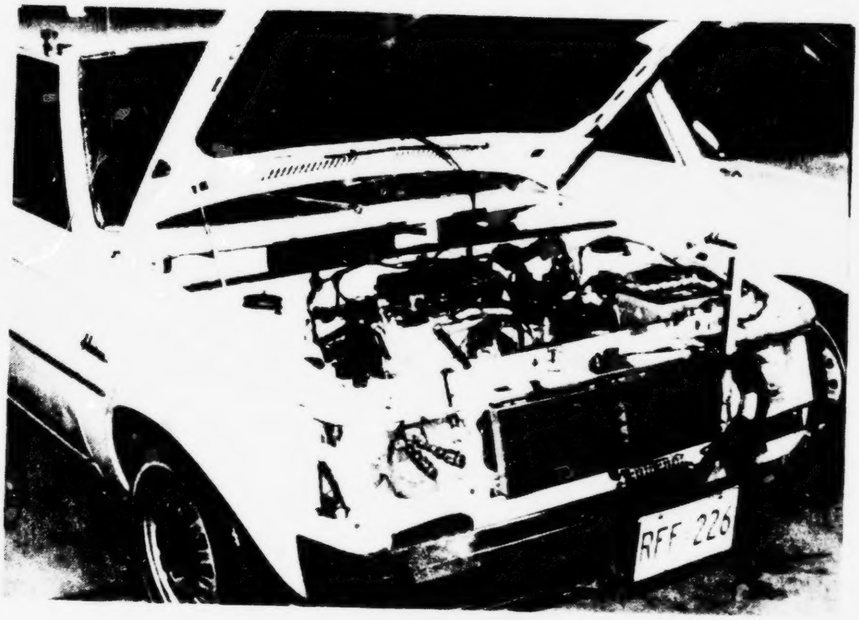


Figure 15 - Winter Front Assembly and Engine Insulation - Overall View

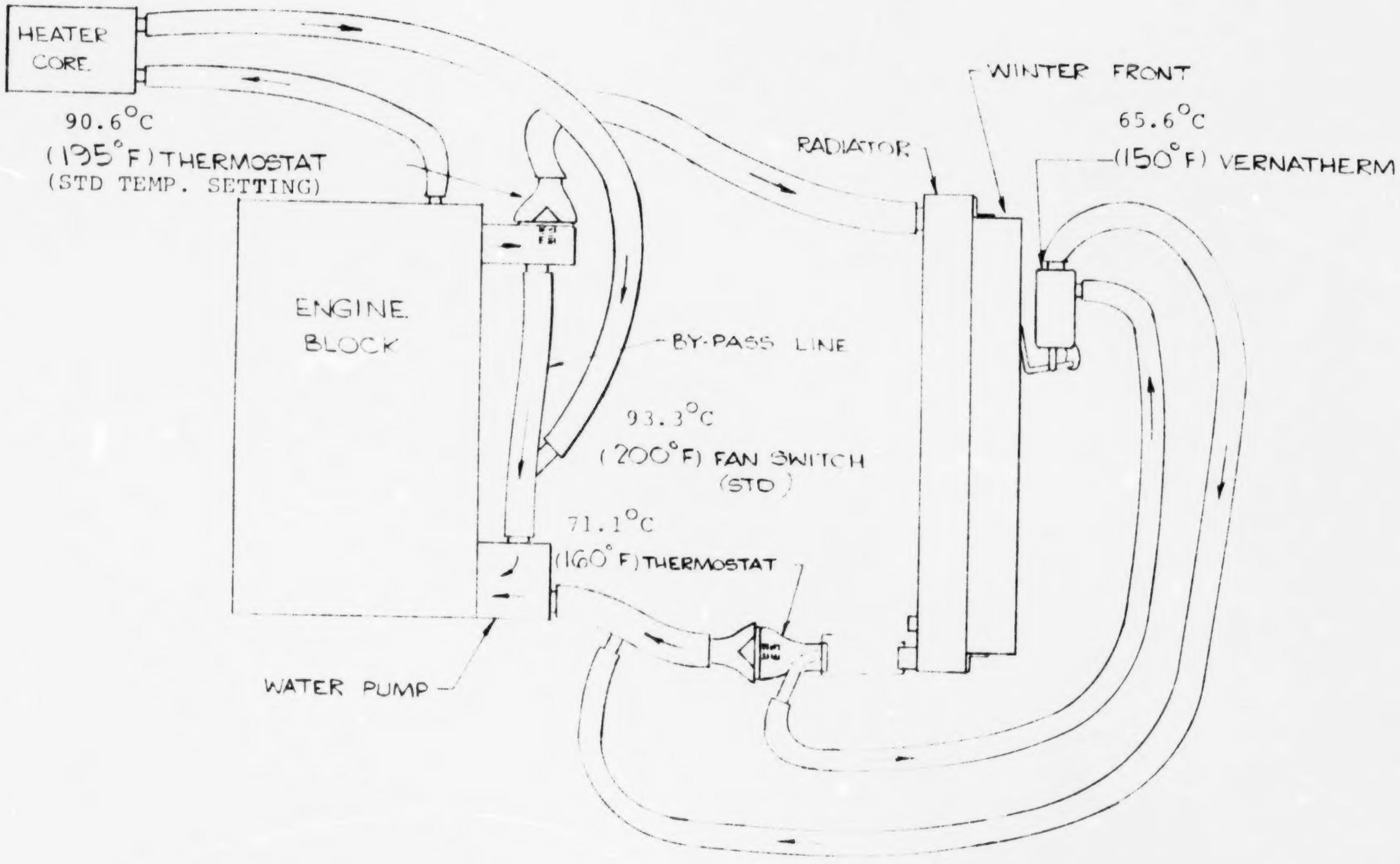

HEATER CORE
90.6°C
(195°F) THERMOSTAT
(STD TEMP. SETTING)
ENGINE BLOCK
WATER PUMP
BY-PASS LINE
93.3°C
(200°F) FAN SWITCH
(STD)
71.1°C
(160°F) THERMOSTAT
RADIATOR
WINTER FRONT
65.6°C
(150°F) VERNATHERM

Figure 16 - Winter Front Plumbing Schematic

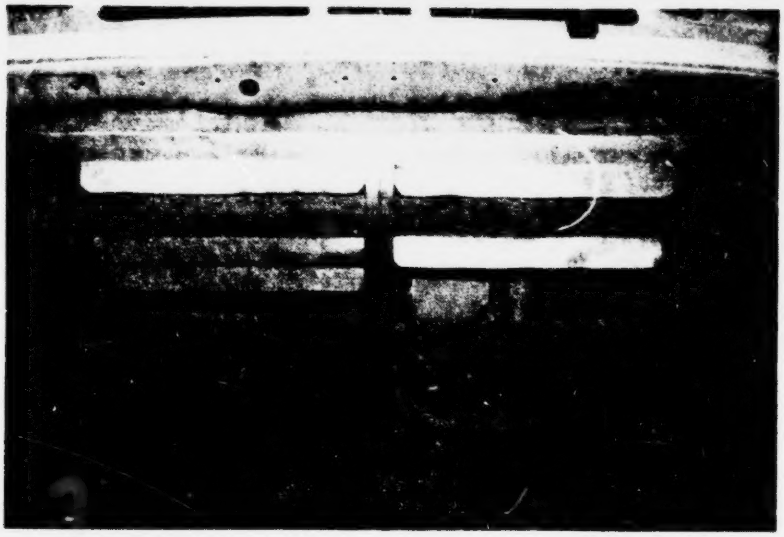


Figure 17 - Under-Engine Pan

Figure 18 - Engine Insulation

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

CITY CYCLE COLD TRANSIENT PARAMETER COMPARISON TRACES

Vehicle Identification No (last six digits): 117590

Vehicle Number: 4 ENGINE BLOCK HEAT CONSERVATION

FUEL CONSUMED VERSUS TIME

(Base Car: 1980 1·7L 'L' car w/ 1979 carb., ESA, dist. & EGR)

(test run with hood closed)

LEGEND

	Test Temp. °C	Hardware Config.
⊡ – 4.1.2–3	25	Base
▷ – 4.1.4–4	-20	"
+ – 4.3.X–1	-20	w/ Blk. Htr. on 4 hrs.
× – 4.4.Y–1	-20	" " 2·5 "
◇ – 4.4.Z–2	-20	" " 1
✱ – 4.5.2–2	25	w/ Blk. Htr. Conserv. Mods.
⊖ – 4.5.4–2	-20	" "
⊕ – 4.7.2–1	25	" "
≺ – 4.7.4–2	-20	" "

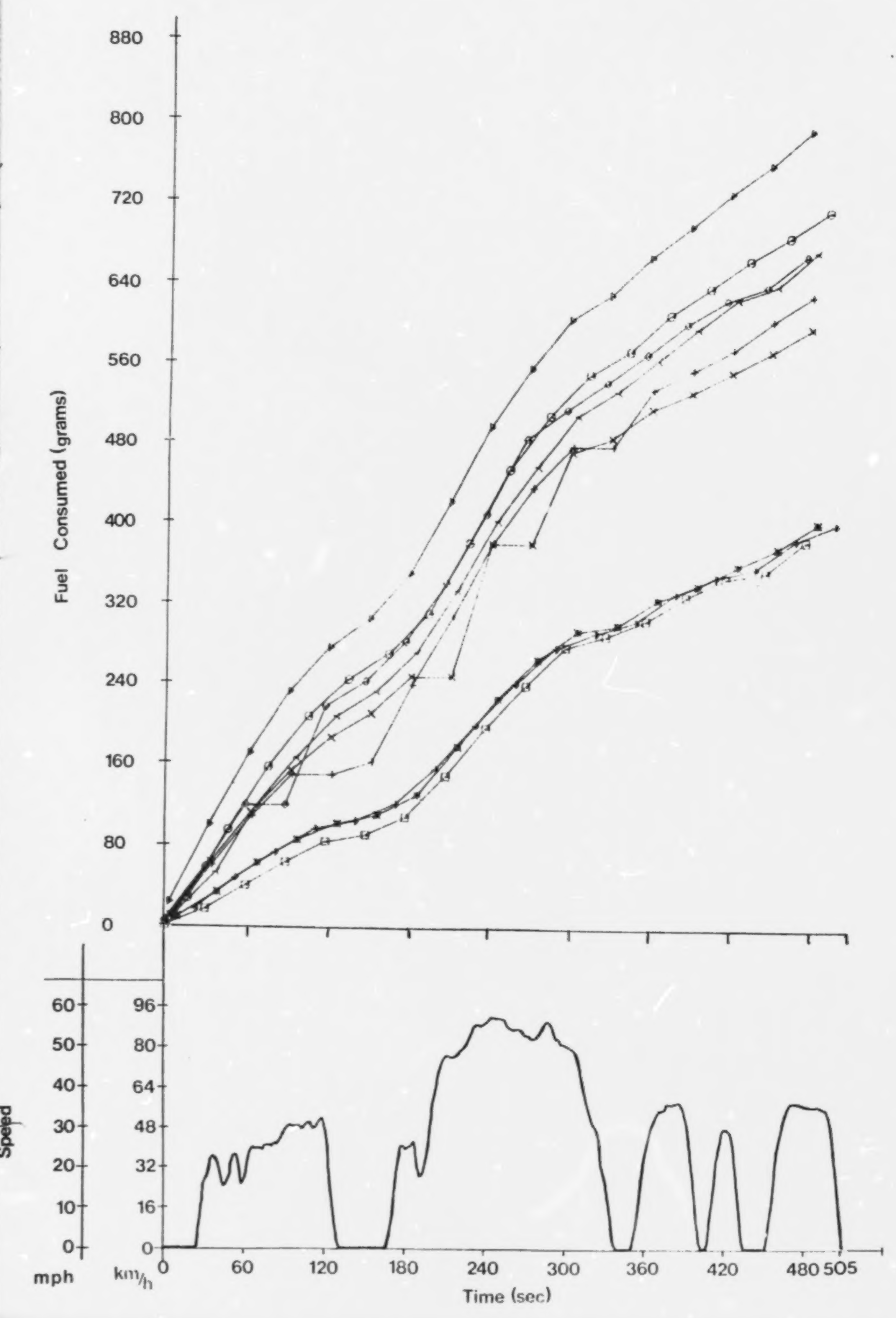


FIGURE 19

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

CITY CYCLE COLD STABILIZED TEMPERATURE AND FUEL CONS. TRACE

Vehicle Identification No (last six digits): 107326

Vehicle Number: 2 EARLY FUEL EVAPORATION

Hardware Configuration: BASE VEHICLE

Base Car: 1980 1·7 L 'L' car w/ 1979 carb., ESA, dist. & EGR)

Test No: 2.1.2-4 Test Temperature: 25 °C

(test run with hood closed)

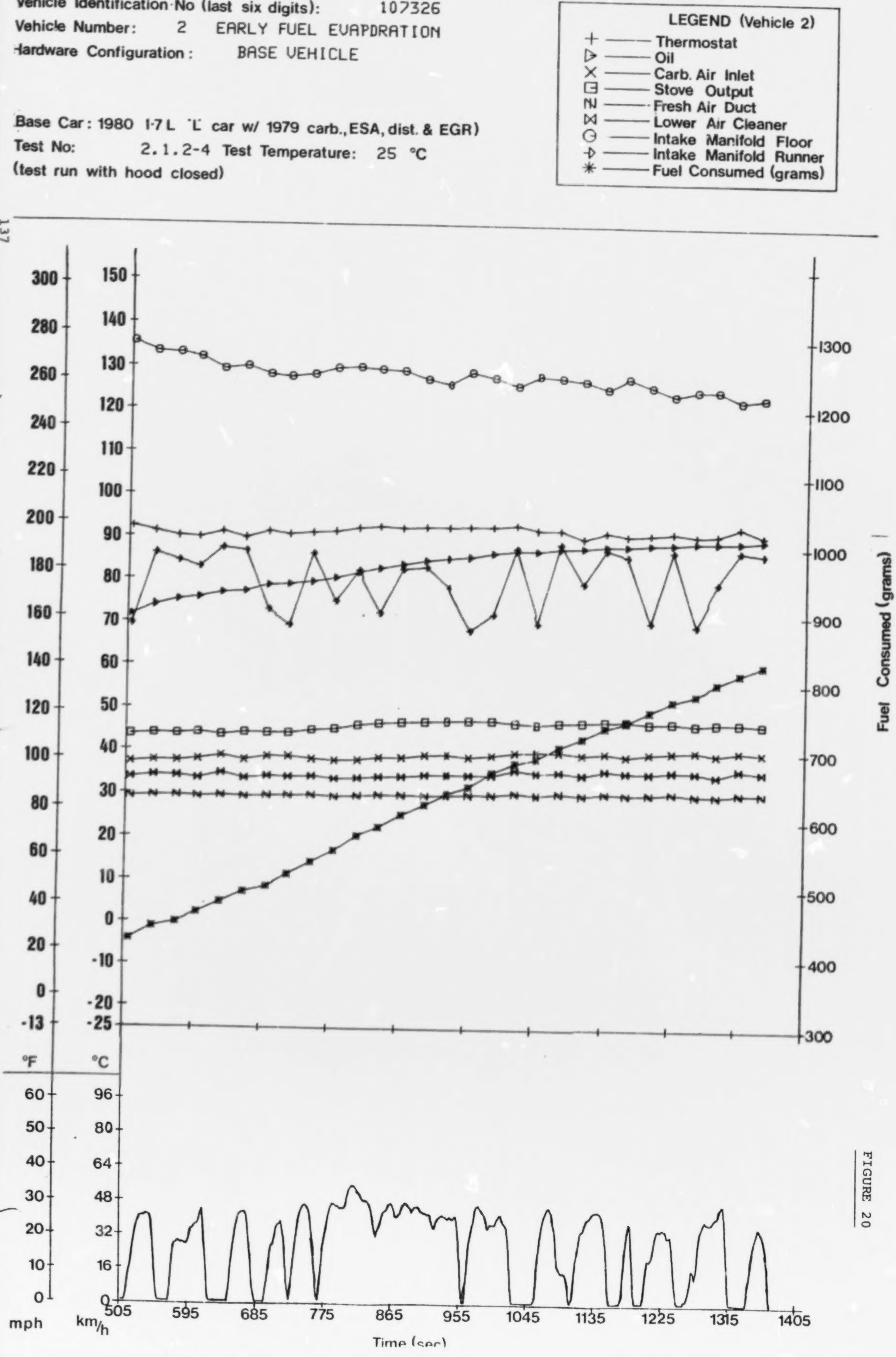


FIGURE 20

CANADA COLD WEATHER TEST PROGRAM

HIGHWAY CYCLE PARAMETER COMPARISON TRACES

Vehicle Identification·No (last six digits): 112590

Vehicle Number: 4 ENGINE BLOCK HEAT CONSERVATION

STOVE OUTPUT TEMPERATURE VERSUS TIME

(Base Car: 1980 1·7L 'L' car w/ 1979 carb., ESA, dist. & EGR)

(test run with hood closed)

LEGEND

	Test Temp. °C	Hardware Config.
□ – 4.1.2–3	25	Base
▷ – 4.1.4–4	-20	"
+ – 4.3.X–1	-20	w/ Blk. Htr. on 4 hrs.
× – 4.4.Y–1	-20	" " 2·5 "
◇ – 4.4.Z–2	-20	" " 1
✱ – 4.5.2–2	25	w/ Blk. Htr. Conserv. Mods.
○ – 4.5.4–2	-20	" "
⊕ – 4.7.2–1	25	" "
≺ – 4.7.4–2	-20	" "

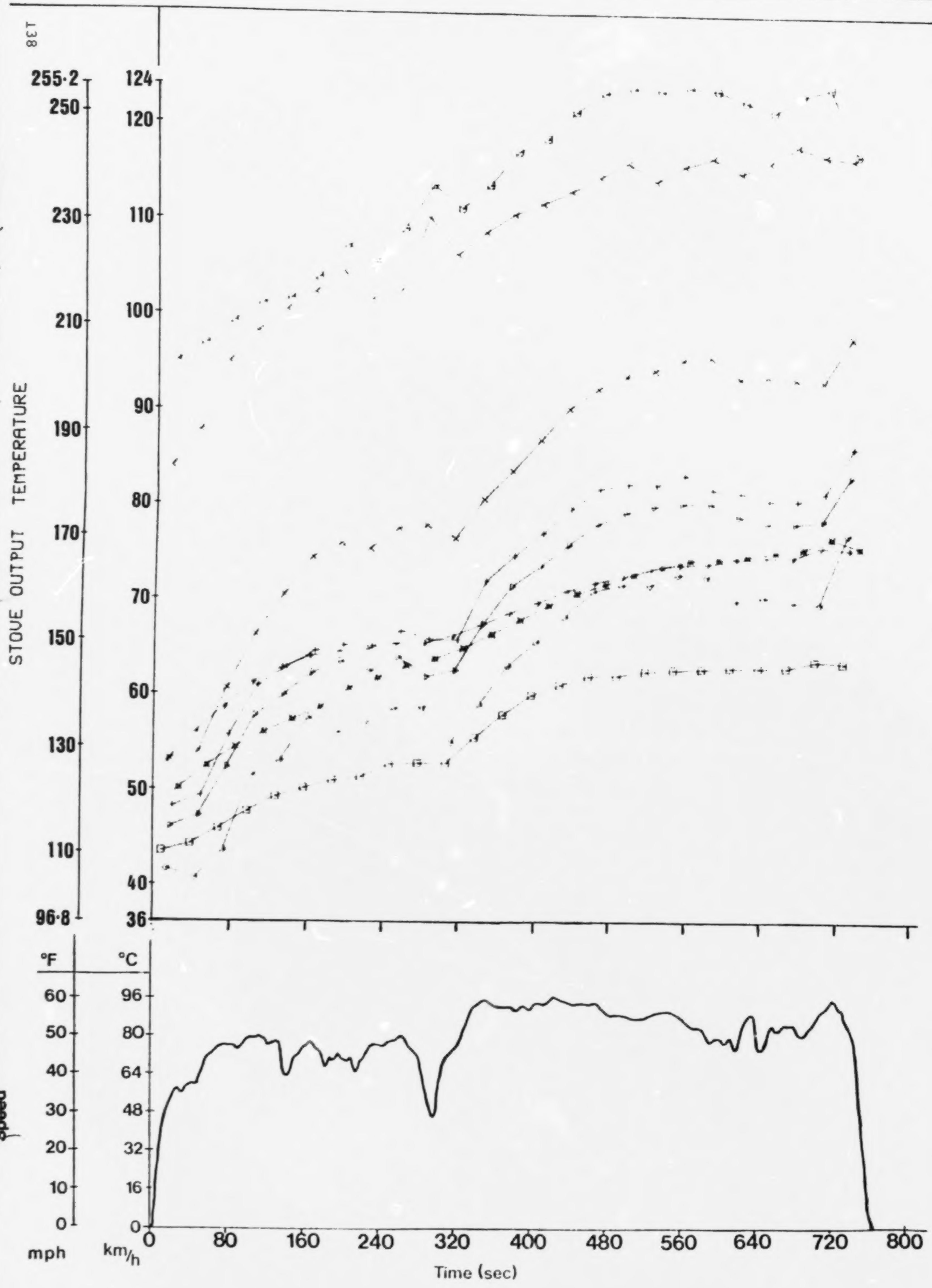


FIGURE 21

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

BLOCK HEATER WARMUP TEMPERATURE TRACES (EXPANDED TEMP SCALE)

Vehicle Identification No (last six digits): **117590**
Vehicle Number: **4** Block Heat Conservation
Run No: **4.2-1** Base Vehicle

4.6-3 With Block Heat Conservation Mods.
(Base Car: 1980 1·7 L 'L' car w/ 1979 carb., ESA, dist. & EGR)
Test Temperature: **-20°C**
(test run with hood closed)

LEGEND

Parameter	Symbol Base	Symbol Modified
Transmission Oil	□	◇
Left Hood	○	⋈
Stove Output	▷	Y
Carb. Air Inlet	×	⌑
Oil	◇	*
Frost Plug	Z	⊠
Thermostat	+	✡

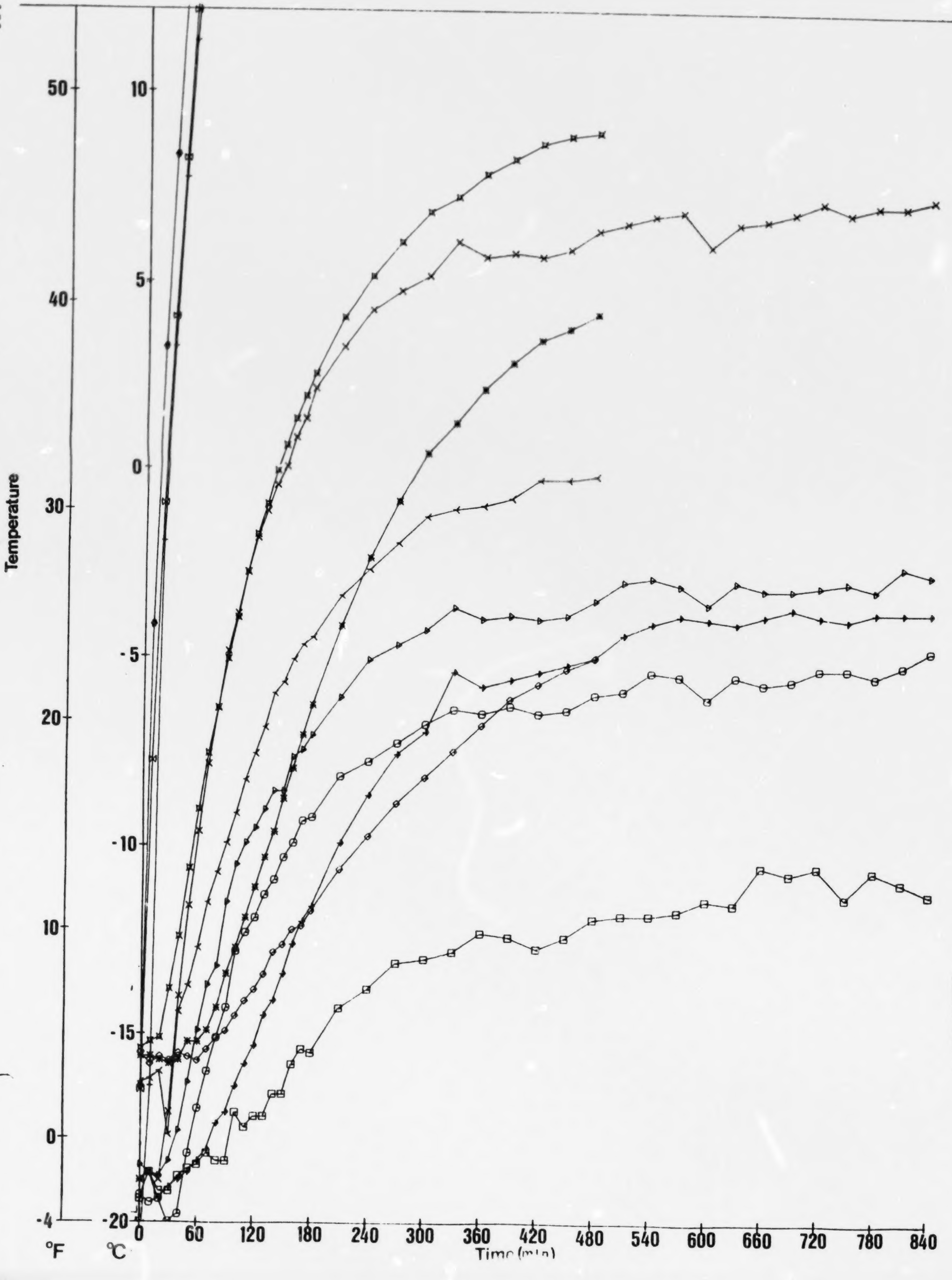


FIGURE 22

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

VEHICLE COOLDOWN TEMPERATURE TRACE (EXPANDED TEMP SCALE)

Vehicle Identification No (last six digits): **117590**

Vehicle Number: **4** Block Heat Conservation

Run No: **4.2-1** Base Vehicle

4.6-3 With Block Heat Conservation Mods.

(Base Car: 1980 1·7 L 'L' car w/ 1979 carb., ESA, dist. & EGR)

Test Temperature: **-20°C**

(test run with hood closed)

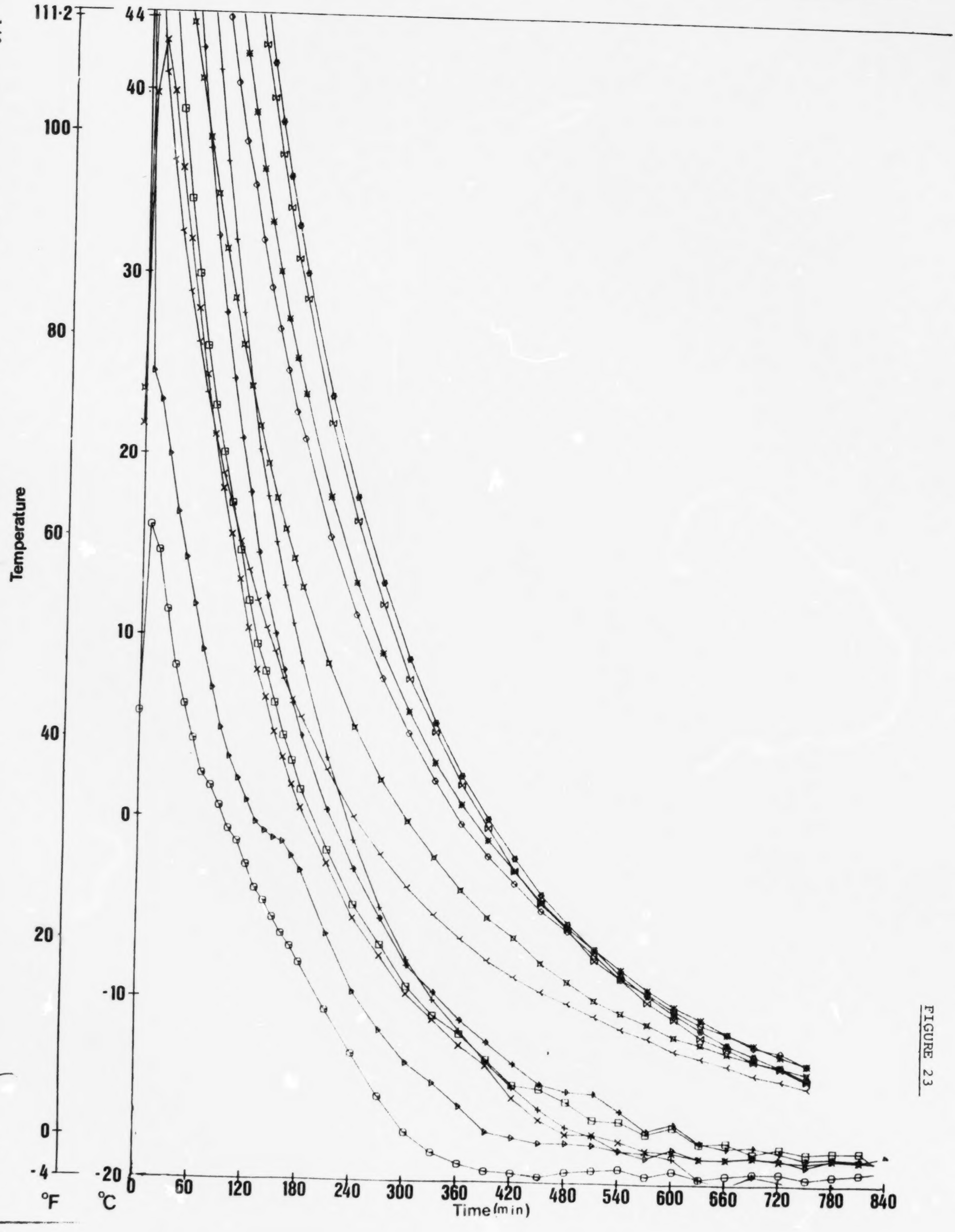


FIGURE 23

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

CITY CYCLE COLD TRANSIENT PARAMETER COMPARISON TRACES

Vehicle Identification No (last six digits): 107326

Vehicle Number: 2 EARLY FUEL EVAPORATION

STOVE OUTPUT TEMPERATURE VERSUS TIME

(Base Car: 1980 1·7 L 'L' car w/ 1979 carb., ESA, dist. & EGR)

(test run with hood closed)

LEGEND

	Test Temp. °C	Hardware Config.
☐ −2.1.2−4	25	Base
▷ −2.1.3−1	0	"
+ −2.1.4−1	−20	"
× −2.2.2−1	25	with EFE Mods.
◇ −2.2.3−2	0	" " "
✱ −2.2.4−3	−20	" " "

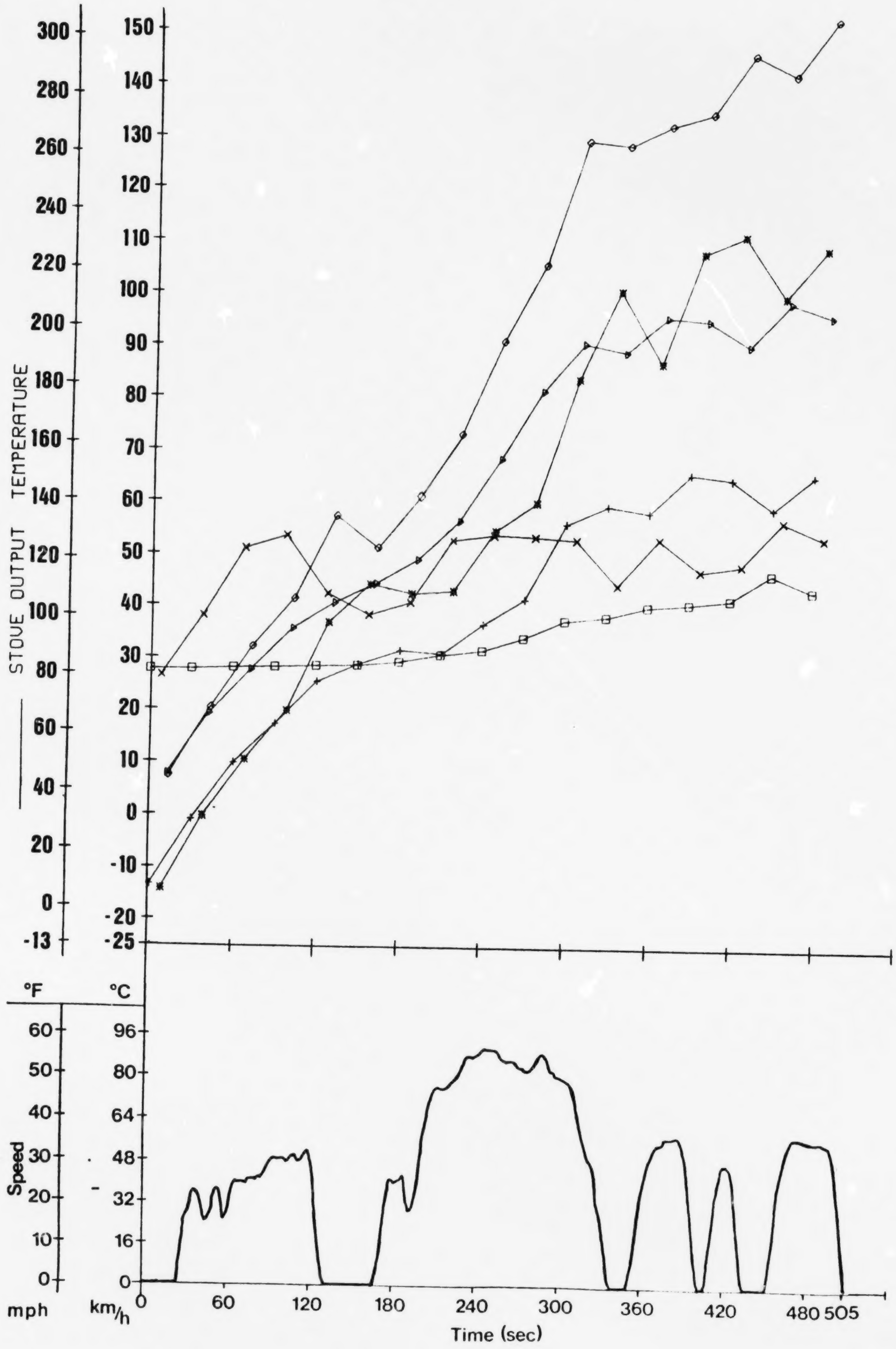


FIGURE 24

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

CITY CYCLE COLD STABILIZED PARAMETER COMPARISON TRACES

Vehicle Identification No (last six digits): 107326

Vehicle Number: 2 EARLY FUEL EVAPORATION

STOVE OUTPUT TEMPERATURE VERSUS TIME

(Base Car: 1980 1·7 L 'L' car w/ 1979 carb., ESA, dist. & EGR)

(test run with hood closed)

LEGEND

	Test Temp. °C	Hardware Config.
□ –2.1.2–4	25	Base
▷ –2.1.3–1	0	"
+ –2.1.4–1	-20	"
× –2.2.2–1	25	with EFE Mods.
◇ –2.2.3–2	0	" " "
✳ –2.2.4–3	-20	" " "

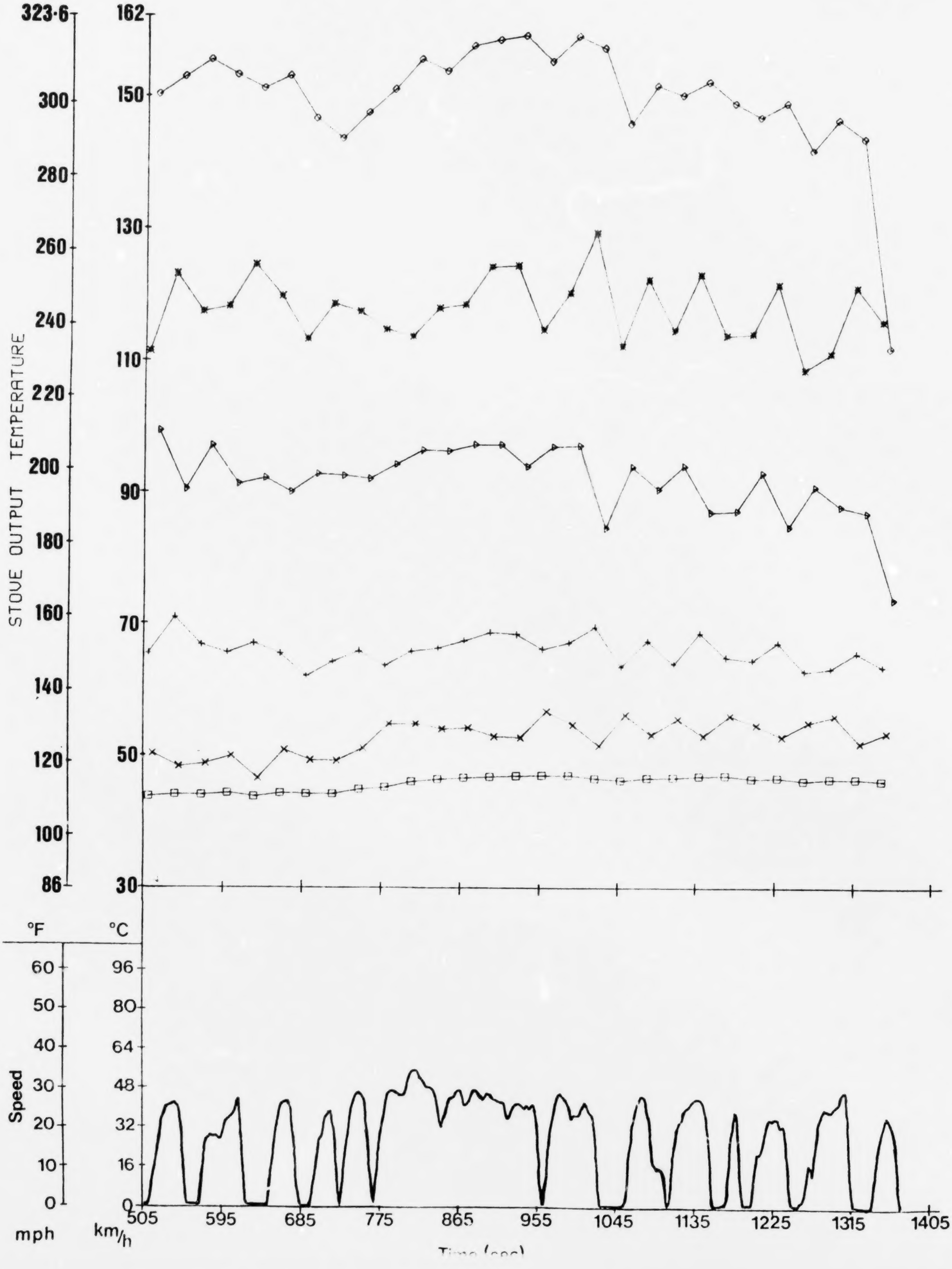


FIGURE 25

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

CITY CYCLE COLD TRANSIENT
Vehicle Identification No (last six digits): 107326
Vehicle Number: 2 EARLY FUEL EVAPORATION

PARAMETER COMPARISON TRACES

CARB AIR INLET TEMPERATURE VERSUS TIME

(Base Car: 1980 1·7 L 'L' car w/ 1979 carb., ESA, dist. & EGR)

(test run with hood closed)

LEGEND

	Test Temp. °C	Hardware Config.
□ −2.1.2−4	25	Base
▷ −2.1.3−1	0	"
+ −2.1.4−1	-20	"
× −2.2.2−1	25	with EFE Mods.
◇ −2.2.3−2	0	" " "
✳ −2.2.4−3	-20	" " "

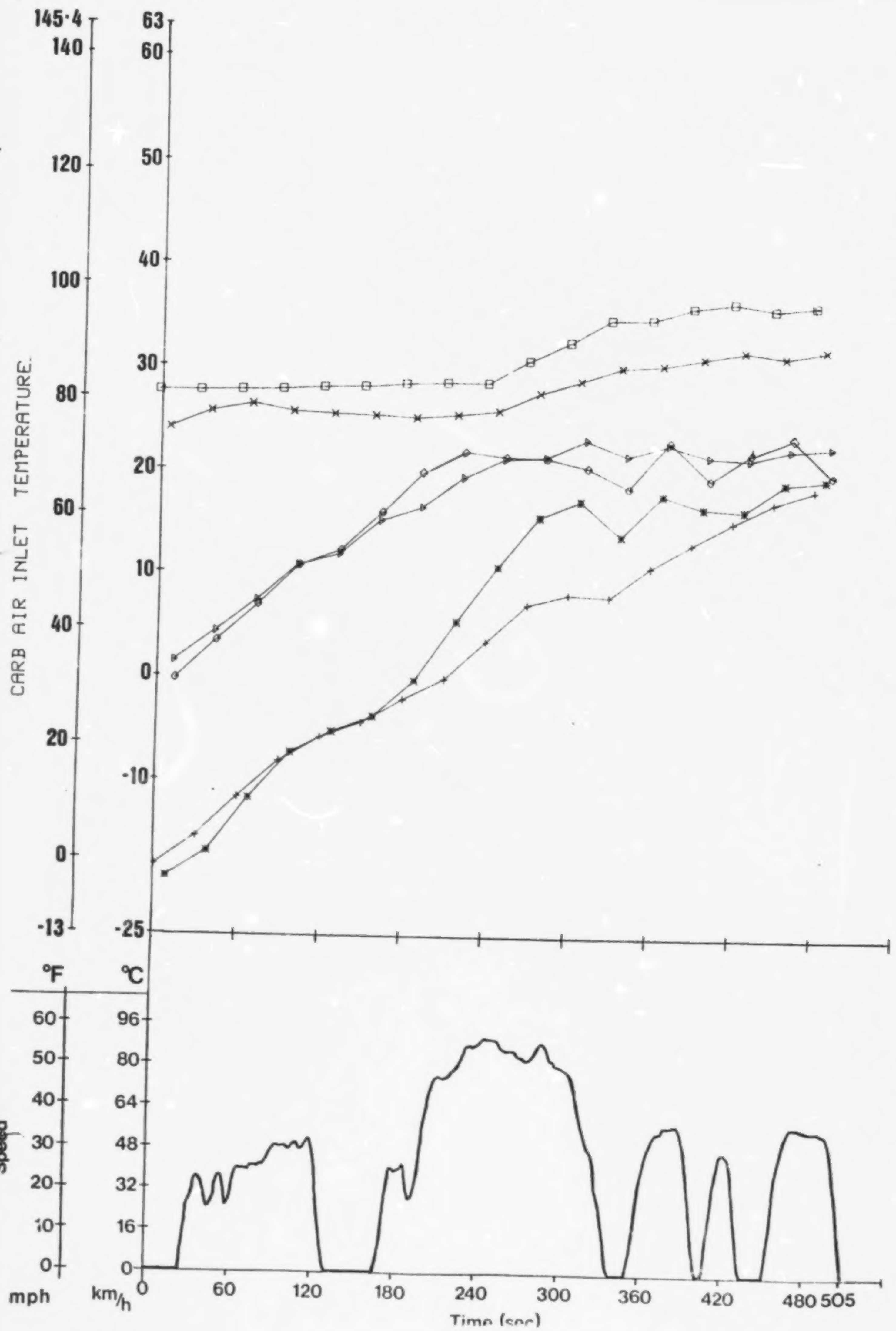


FIGURE 26

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

CITY CYCLE COLD STABILIZED PARAMETER COMPARISON TRACES

Vehicle Identification No (last six digits): 107326

Vehicle Number: 2 EARLY FUEL EVAPORATION

CARB AIR INLET TEMPERATURE VERSUS TIME

(Base Car: 1980 1·7 L 'L' car w/ 1979 carb., ESA, dist. & EGR)

(test run with hood closed)

LEGEND

	Test Temp. °C	Hardware Config.
⊡ −2.1.2−4	25	Base
▷ −2.1.3−1	0	"
+ −2.1.4−1	−20	"
× −2.2.2−1	25	with EFE Mods.
◇ −2.2.3−2	0	" " "
✱ −2.2.4−3	−20	" " "

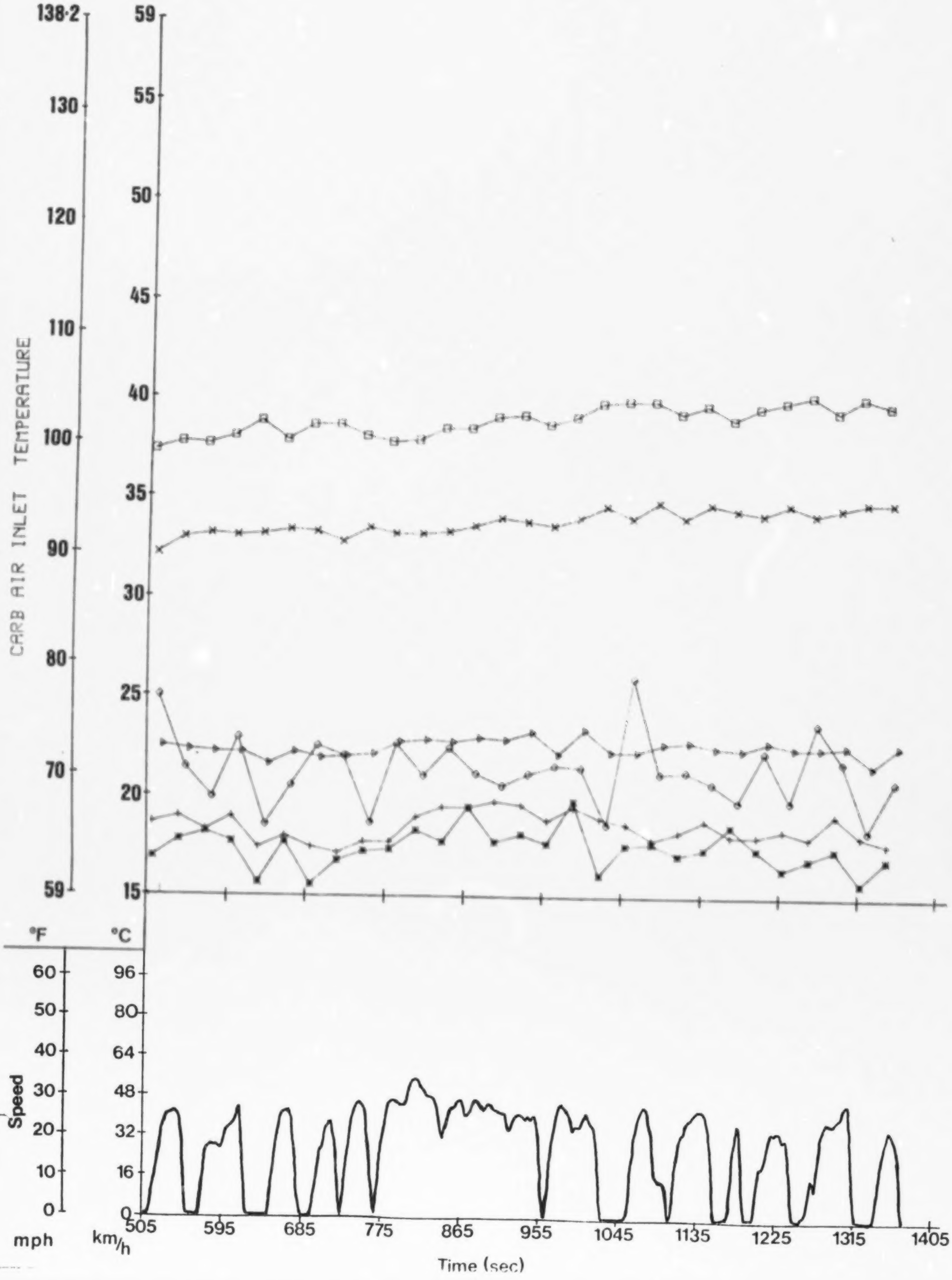


FIGURE 27

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

CITY CYCLE SOAK & HOT TRANSIENT PARAMETER COMPARISON TRACES

Vehicle Identification No (last six digits): 107326

Vehicle Number: 2 EARLY FUEL EVAPORATION

——CARB AIR INLET TEMPERATURE VERSUS TIME

(Base Car: 1980 1·7 L 'L' car w/ 1979 carb., ESA, dist. & EGR)

(test run with hood closed)

LEGEND

	Test Temp. °C	Hardware Config.
⊡ – 2.1.2-4	25	Base
▷ – 2.1.3-1	0	"
+ – 2.1.4-1	-20	"
× – 2.2.2-1	25	with EFE Mods.
◇ – 2.2.3-2	0	" " "
✳ – 2.2.4-3	-20	" " "

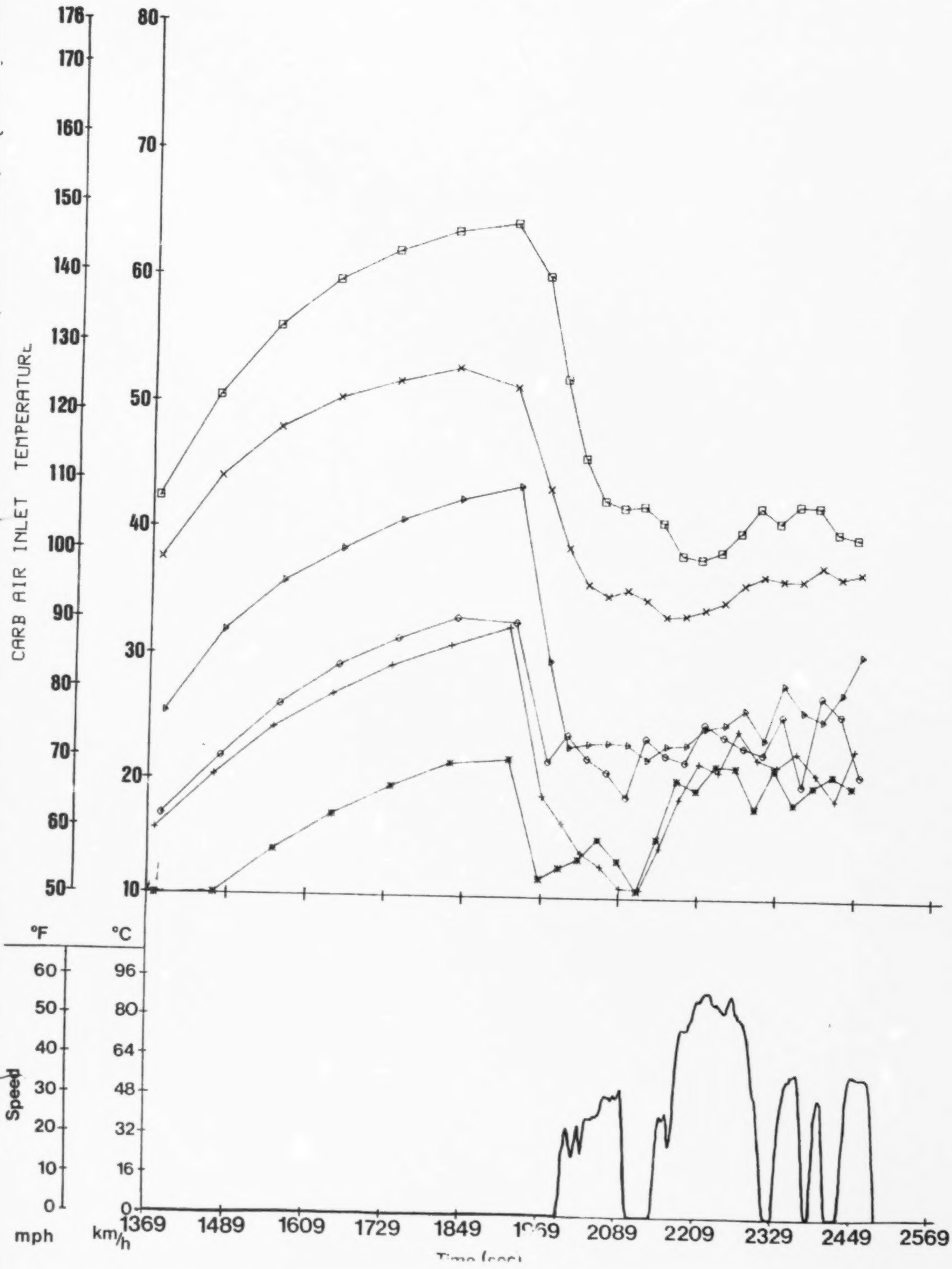


FIGURE 28

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

CITY CYCLE COLD TRANSIENT PARAMETER COMPARISON TRACES

Vehicle Identification No (last six digits): 107326

Vehicle Number: 2 EARLY FUEL EVAPORATION

INTAKE MANIFOLD RUNNER TEMPERATURE VERSUS TIME

(Base Car: 1980 1·7 L 'L' car w/ 1979 carb., ESA, dist. & EGR)

(test run with hood closed)

LEGEND

	Test Temp. °C	Hardware Config.
□ – 2.1.2–4	25	Base
▷ – 2.1.3–1	0	"
+ – 2.1.4–1	-20	"
× – 2.2.2–1	25	with EFE Mods.
◇ – 2.2.3–2	0	" " "
✱ – 2.2.4–3	-20	" " "

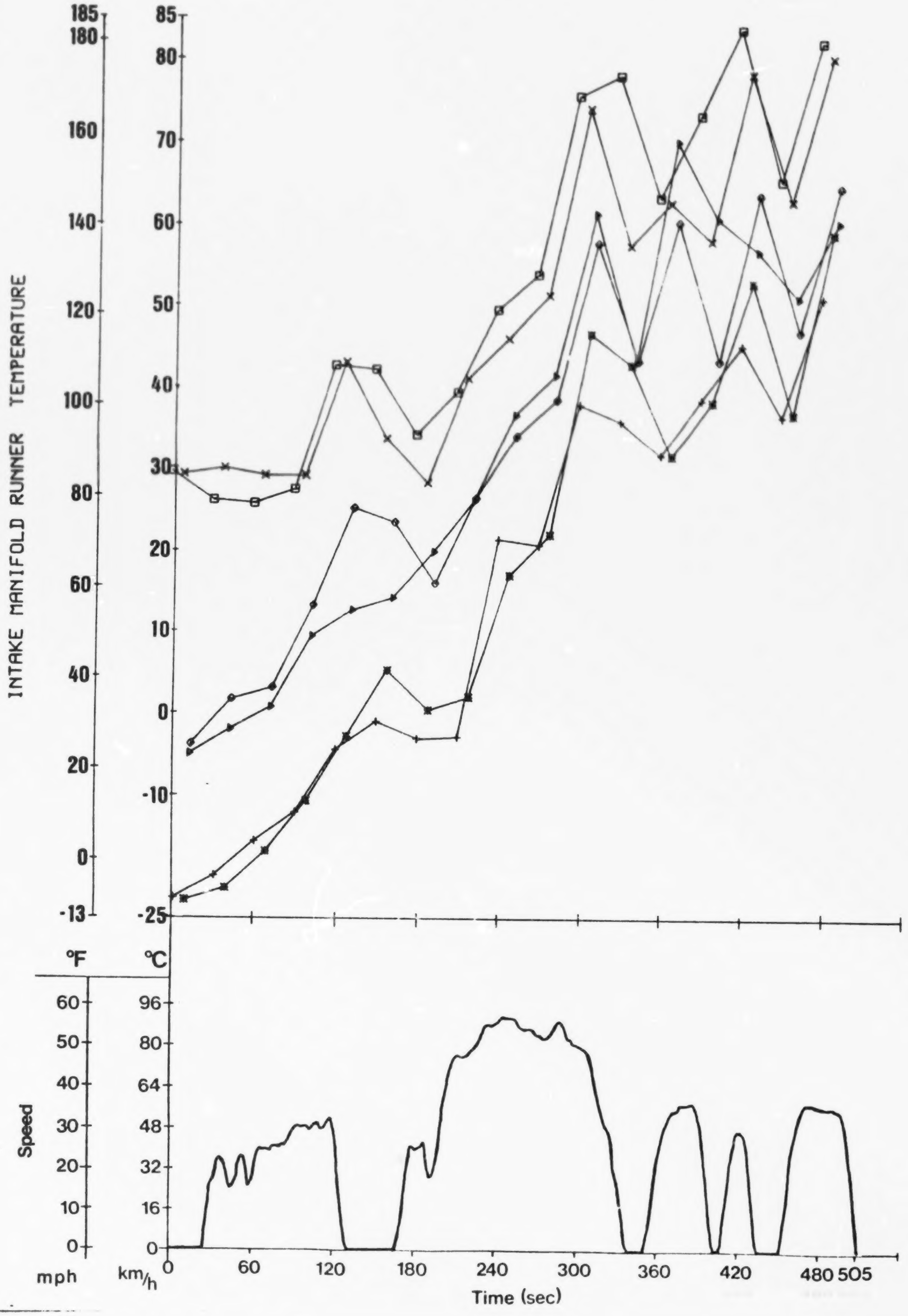


FIGURE 29

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

HIGHWAY CYCLE   PARAMETER COMPARISON TRACES

Vehicle Identification No (last six digits): [illegible]

Vehicle Number: 4   ENGINE BLOCK HEAT COMPARISON

OIL   TEMPERATURE VERSUS TIME

(Base Car: 1980 1·7 L 'L' car w/ 1979 carb., ESA, dist. & EGR)

(test run with hood closed)

LEGEND

	Test Temp. °C	Hardware Config.
◻ – 4.1.2–3	25	Base
▷ – 4.1.4–4	-20	"
+ – 4.3.X–1	-20	w/ Blk. Htr. on 4 hrs.
× – 4.4.Y–1	-20	" " 2·5 "
◇ – 4.4.Z–2	-20	" " 1
✱ – 4.5.2–2	25	w/ Blk. Htr. Conserv. Mods.
○ – 4.5.4–2	-20	" "
⊕ – 4.7.2–1	25	" "
≺ – 4.7.4–2	-20	" "

147

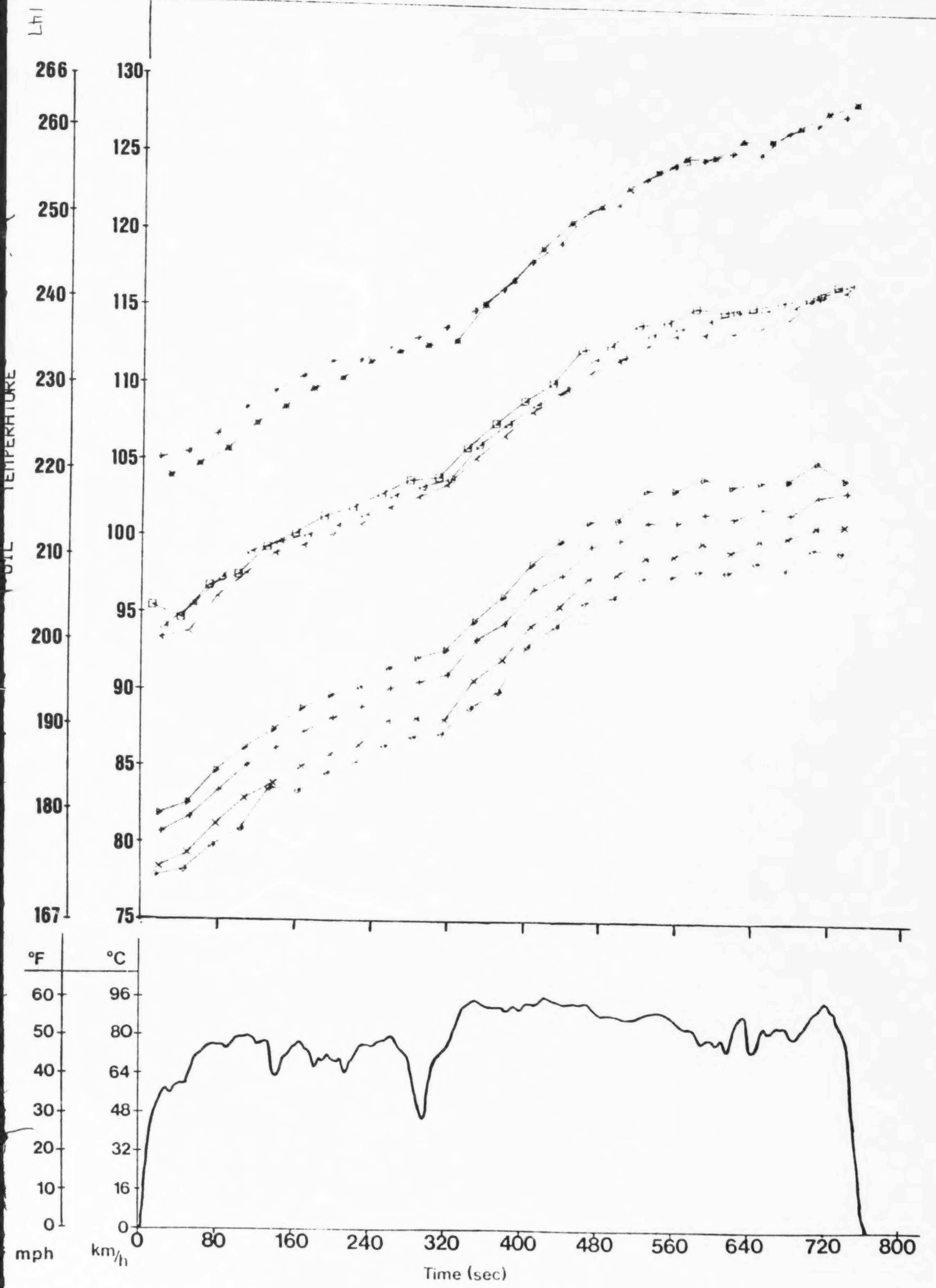


FIGURE 30

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

HIGHWAY CYCLE PARAMETER COMPARISON TRACES

Vehicle Identification·No (last six digits): 119590

Vehicle Number: 4 ENGINE BLOCK HEAT CONSERVATION

TRANSMISSION OIL TEMPERATURE VERSUS TIME

(Base Car: 1980 1·7 L 'L' car w/ 1979 carb., ESA, dist. & EGR)

(test run with hood closed)

LEGEND

	Test Temp. °C	Hardware Config.
☐ – 4.1.2–3	25	Base
▷ – 4.1.4–4	-20	"
+ – 4.3.X–1	-20	w/ Blk. Htr. on 4 hrs.
× – 4.4.Y–1	-20	" " 2·5 "
◇ – 4.4.Z–2	-20	" " 1
✱ – 4.5.2–2	25	w/ Blk. Htr. Conserv. Mods.
⊖ – 4.5.4–2	-20	" "
⊕ – 4.7.2–1	25	" "
⋎ – 4.7.4–2	-20	" "

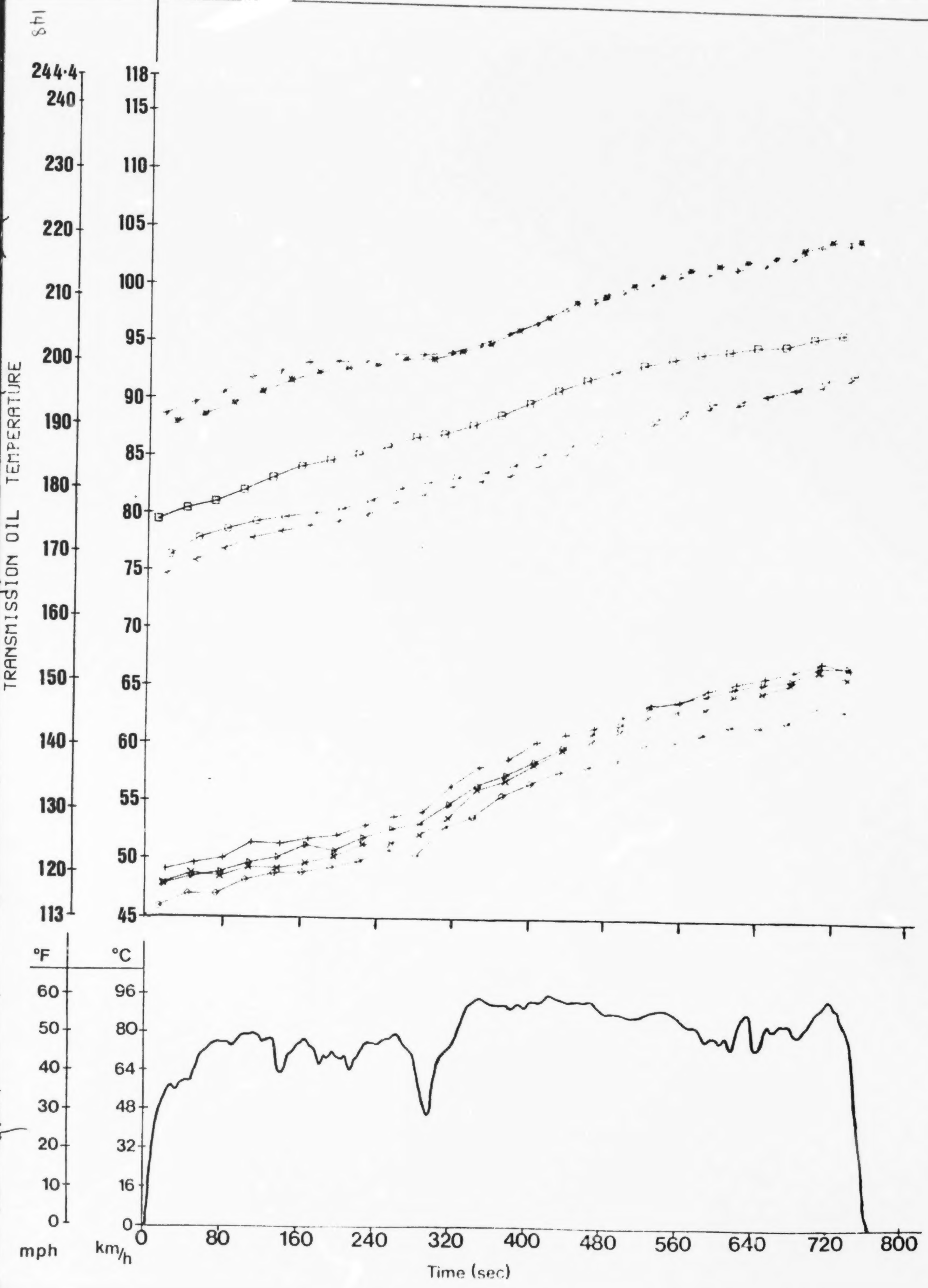


FIGURE 31

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

VEHICLE COOLDOWN TEMPERATURE TRACE

Vehicle Identification No (last six digits): **117590**

Vehicle Number: 4 Block Heat Conservation

Run No: 4.2-1 Base Vehicle

4.6-3 With Block Heat Conservation Mods.

(Base Car: 1980 1·7 L 'L' car w/ 1979 carb., ESA, dist. & EGR)

Test Temperature: **-20°C**

(test run with hood closed)

LEGEND

Parameter	Symbol Base	Symbol Modified
Transmission Oil	⊡	◇
Left Hood	○	⋈
Stove Output	△	Y
Carb. Air Inlet	×	⌑
Oil	◁	✱
Frost Plug	Z	⊠
Thermostat	+	✡

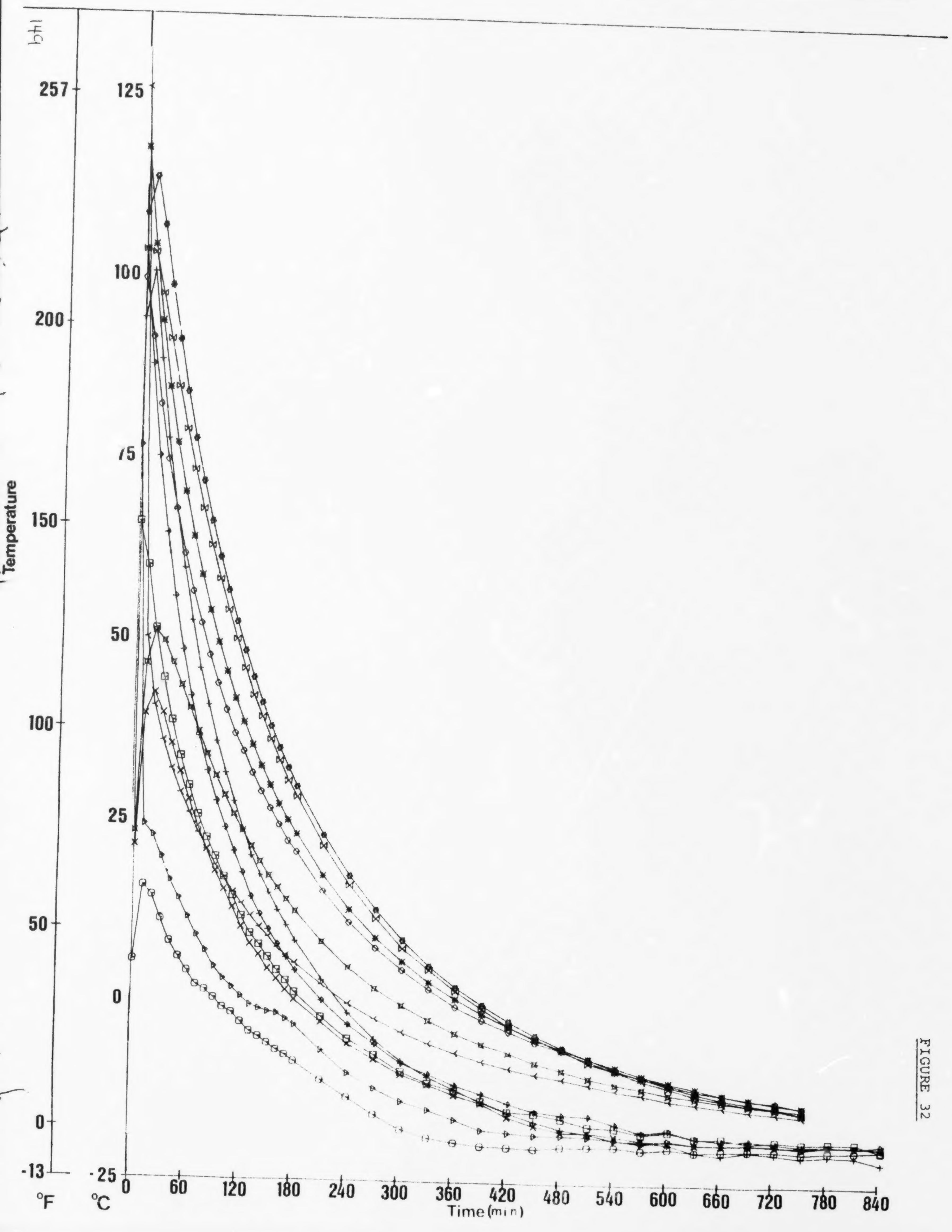


FIGURE 32

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

CITY CYCLE COLD TRANSIENT PARAMETER COMPARISON TRACES

Vehicle Identification No (last six digits): 117590

Vehicle Number: 4 ENGINE BLOCK HEAT CONSERVATION

FROST PLUG TEMPERATURE VERSUS TIME

(Base Car: 1980 1·7 L 'L' car w/ 1979 carb., ESA, dist. & EGR)

(test run with hood closed)

LEGEND

	Test Temp. °C	Hardware Config.
⊡ – 4.1.2 – 3	25	Base
▷ – 4.1.4 – 4	-20	"
+ – 4.3.X – 1	-20	w/ Blk. Htr. on 4 hrs.
× – 4.4.Y – 1	-20	" " 2·5 "
◇ – 4.4.Z – 2	-20	" " 1
✱ – 4.5.2 – 2	25	w/ Blk. Htr. Conserv. Mods.
○ – 4.5.4 – 2	-20	" "
⊕ – 4.7.2 – 1	25	" "
≺ – 4.7.4 – 2	-20	" "

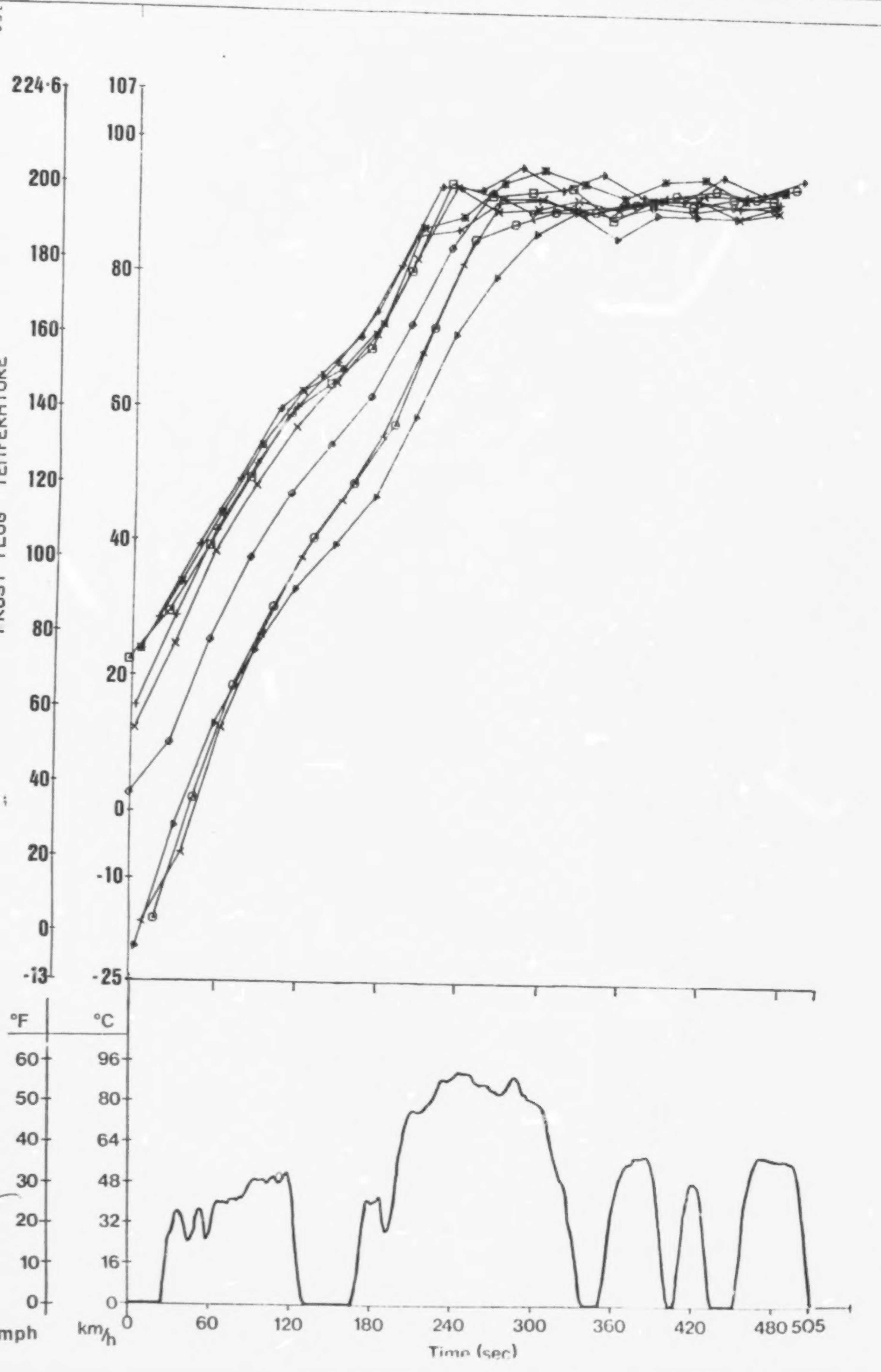


FIGURE 33

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

CITY CYCLE COLD TRANSIENT PARAMETER COMPARISON TRACES

Vehicle Identification·No (last six digits): 117590

Vehicle Number: 4 ENGINE BLOCK HEAT CONSERVATION

THERMOSTAT TEMPERATURE VERSUS TIME

(Base Car: 1980 1·7 L 'L' car w/ 1979 carb., ESA, dist. & EGR)

(test run with hood closed)

LEGEND

	Test Temp. °C	Hardware Config.
⊡ – 4.1.2–3	25	Base
▷ – 4.1.4–4	-20	"
+ – 4.3.X–1	-20	w/ Blk. Htr. on 4 hrs.
× – 4.4.Y–1	-20	" " 2·5 "
◇ – 4.4.Z–2	-20	" " 1
✱ – 4.5.2–2	25	w/ Blk. Htr. Conserv. Mods.
○ – 4.5.4–2	-20	" "
⊕ – 4.7.2–1	25	" "
⋌ – 4.7.4–2	-20	" "

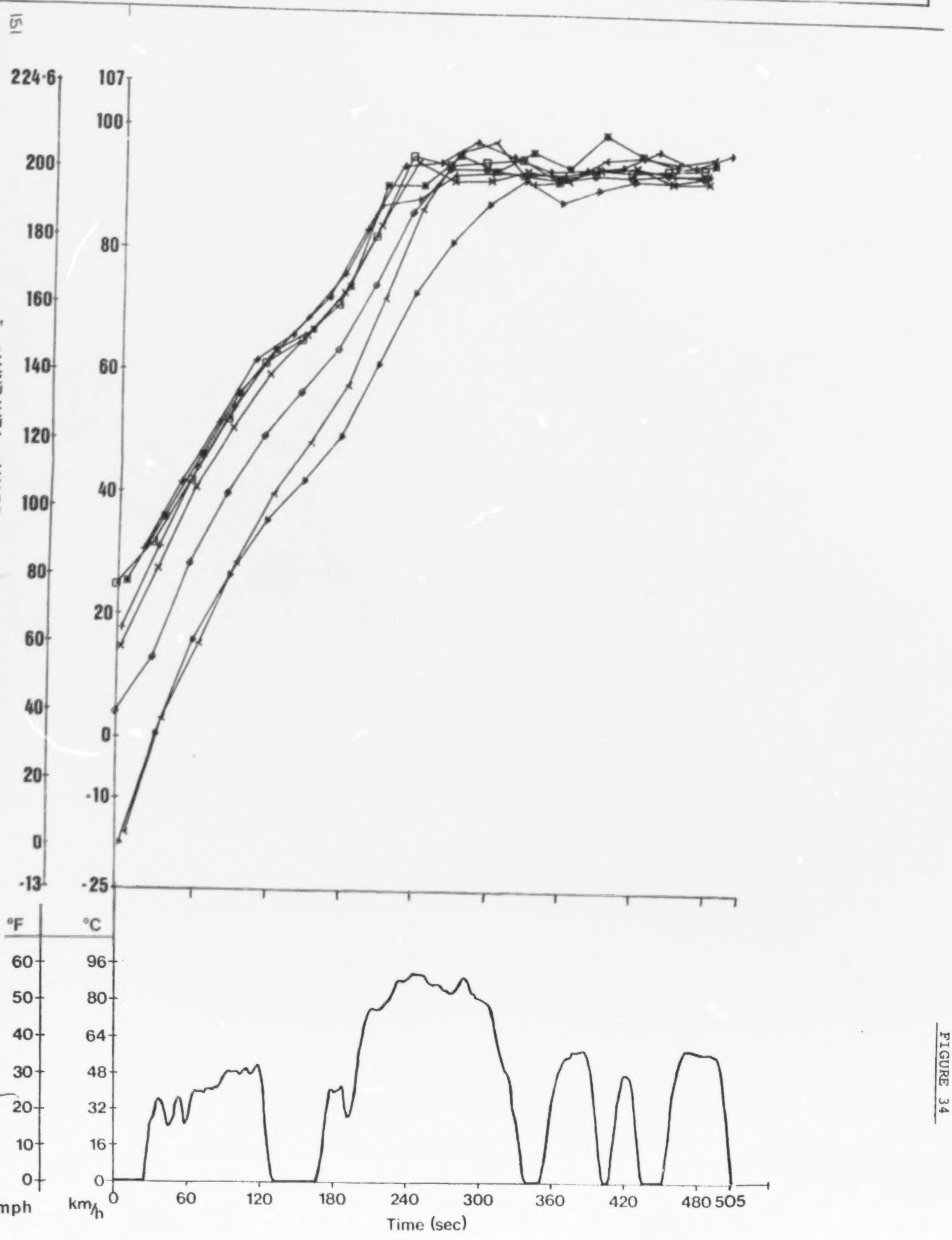


FIGURE 34

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

CITY CYCLE SOAK & HOT TRANSIENT PARAMETER COMPARISON TRACES

Vehicle Identification No (last six digits): 117590

Vehicle Number: 4 ENGINE BLOCK HEAT CONSERVATION

FROST PLUG TEMPERATURE VERSUS TIME

(Base Car: 1980 1·7 L 'L' car w/ 1979 carb., ESA, dist. & EGR)

(test run with hood closed)

LEGEND

	Test Temp. °C	Hardware Config.
□ – 4.1.2–3	25	Base
▷ – 4.1.4–4	-20	"
+ – 4.3.X–1	-20	w/ Blk. Htr. on 4 hrs.
× – 4.4.Y–1	-20	" " 2·5 "
◇ – 4.4.Z–2	-20	" " 1
✱ – 4.5.2–2	25	w/ Blk. Htr. Conserv. Mods.
○ – 4.5.4–2	-20	" "
⌖ – 4.7.2–1	25	" "
≺ – 4.7.4–2	-20	" "

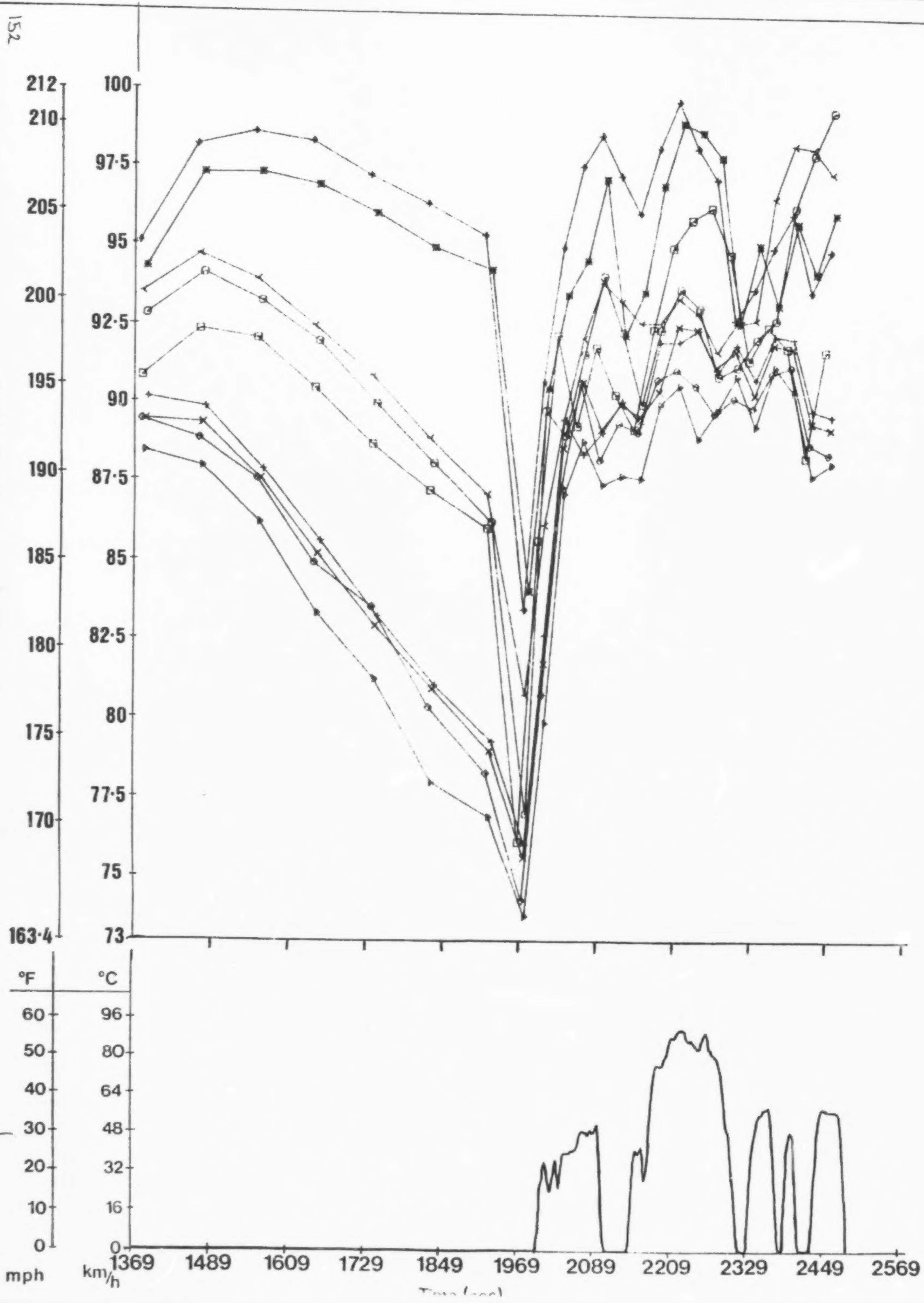


FIGURE 35

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

HIGHWAY CYCLE PARAMETER COMPARISON TRACES

Vehicle Identification No (last six digits): 112590

Vehicle Number: 4 ENGINE BLOCK HEAT CONSERVATION

FROST PLUG TEMPERATURE VERSUS TIME

(Base Car: 1980 1·7L 'L' car w/ 1979 carb., ESA, dist. & EGR)

(test run with hood closed)

LEGEND

	Test Temp. °C	Hardware Config.
□ – 4.1.2–3	25	Base
▷ – 4.1.4–4	-20	"
+ – 4.3.X–1	-20	w/ Blk. Htr. on 4 hrs.
× – 4.4.Y–1	-20	" " 2·5 "
◇ – 4.4.Z–2	-20	" " 1
* – 4.5.2–2	25	w/ Blk. Htr. Conserv. Mods.
○ – 4.5.4–2	-20	" "
⊕ – 4.7.2–1	25	" "
⤙ – 4.7.4–2	-20	" "

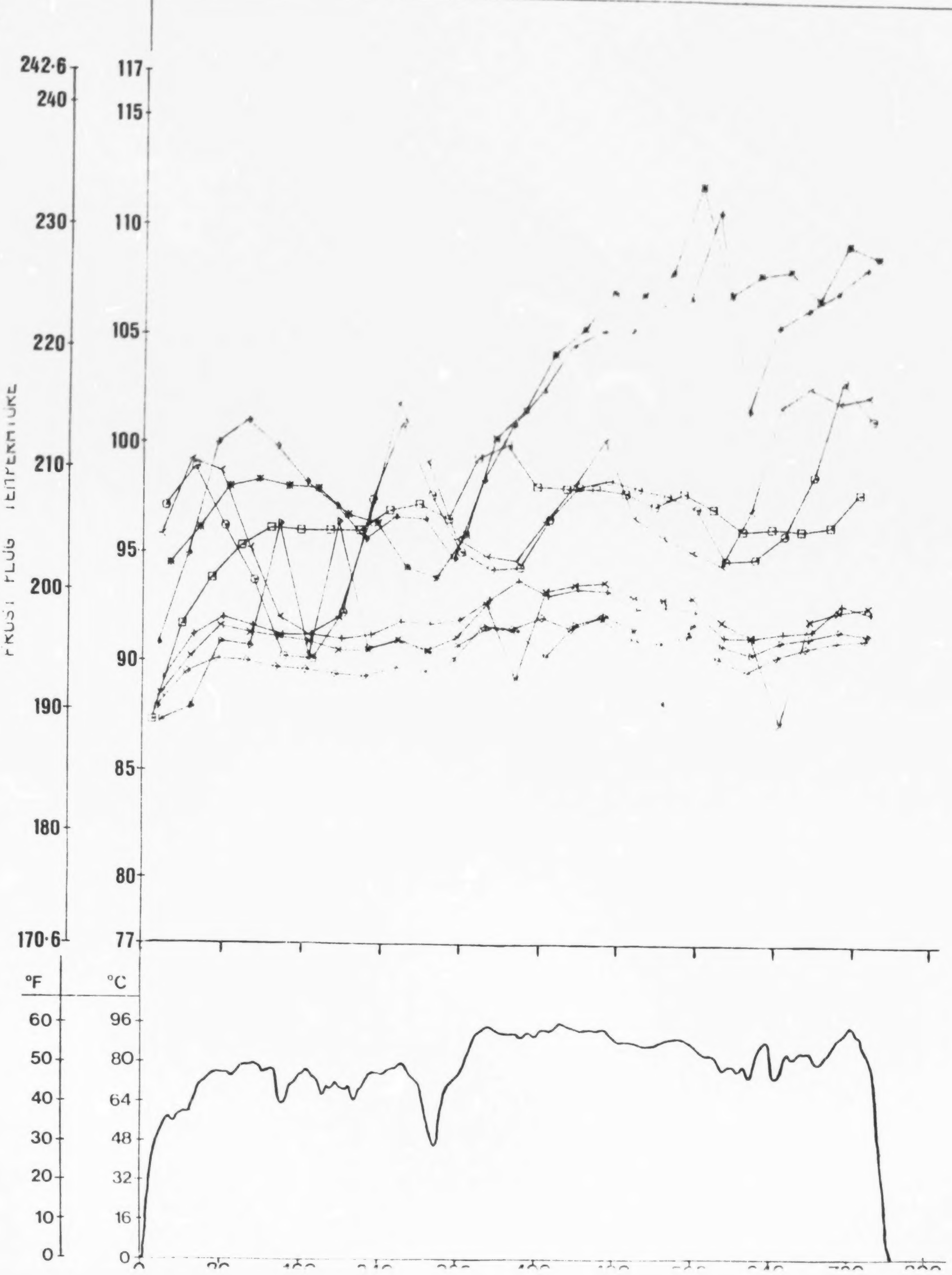


FIGURE 36

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

CITY CYCLE COLD STABILIZED PARAMETER COMPARISON TRACES

Vehicle Identification No (last six digits): 117590

Vehicle Number: 4 ENGINE BLOCK HEAT CONSERVATION

STOVE OUTPUT TEMPERATURE VERSUS TIME

(Base Car: 1980 1·7L 'L' car w/ 1979 carb., ESA, dist. & EGR)

(test run with hood closed)

LEGEND

	Test Temp. °C	Hardware Config.
□ – 4.1.2–3	25	Base
▷ – 4.1.4–4	-20	"
+ – 4.3.X–1	-20	w/ Blk. Htr. on 4 hrs.
× – 4.4.Y–1	-20	" " 2·5 "
◇ – 4.4.Z–2	-20	" " 1
✱ – 4.5.2–2	25	w/ Blk. Htr. Conserv. Mods.
⊖ – 4.5.4–2	-20	" "
⊕ – 4.7.2–1	25	" "
≺ – 4.7.4–2	-20	" "

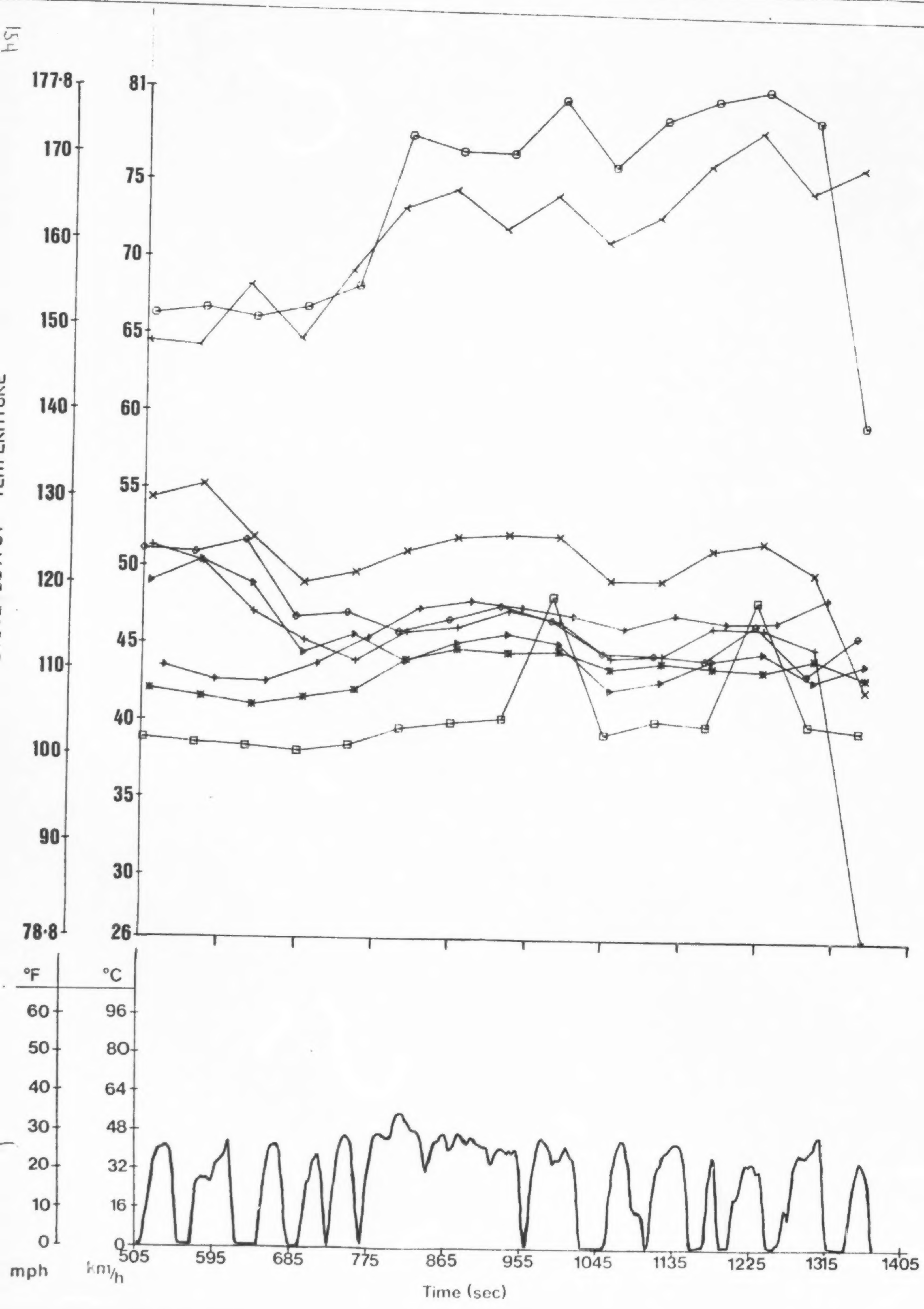


FIGURE 37

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

CITY CYCLE COLD STABILIZED PARAMETER COMPARISON TRACES

Vehicle Identification No (last six digits): 1?2590

Vehicle Number: 4 ENGINE BLOCK HEAT CONSERVATION

CARB AIR INLET TEMPERATURE VERSUS TIME

(Base Car: 1980 1·7L 'L' car w/ 1979 carb., ESA, dist. & EGR)

(test run with hood closed)

LEGEND

	Test Temp. °C	Hardware Config.
⊡ – 4.1.2–3	25	Base
▷ – 4.1.4–4	–20	"
+ – 4.3.X–1	–20	w/ Blk. Htr. on 4 hrs.
× – 4.4.Y–1	–20	" " 2·5 "
◇ – 4.4.Z–2	–20	" " 1
✱ – 4.5.2–2	25	w/ Blk. Htr. Conserv. Mods.
⊙ – 4.5.4–2	–20	" "
⊹ – 4.7.2–1	25	" "
⋌ – 4.7.4–2	–20	" "

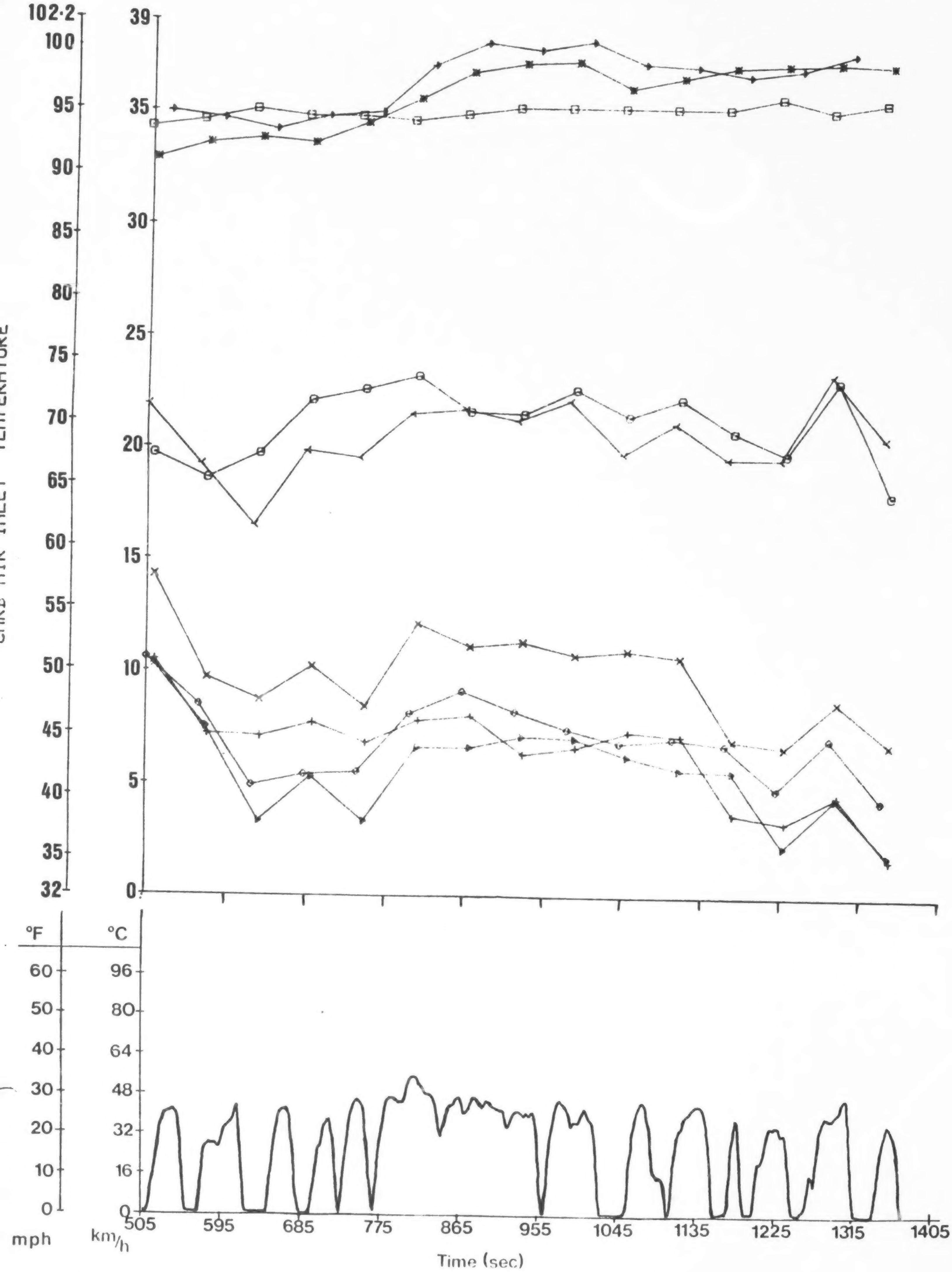


FIGURE 38

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

BLOCK HEATER WARMUP TEMPERATURE TRACES

Vehicle Identification No (last six digits): 117590

Vehicle Number: 4 Block Heat Conservation

Run No: 4.2-1 Base Vehicle

4.6-3 With Block Heat Conservation Mods.

(Base Car: 1980 1·7L 'L' car w/ 1979 carb., ESA, dist. & EGR)

Test Temperature: -20°C

(test run with hood closed)

LEGEND

Parameter	Symbol Base	Symbol Modified
Transmission Oil	⊟	◇
Left Hood	⊖	⋊
Stove Output	▷	⋎
Carb. Air Inlet	×	⌑
Oil	⊹	✱
Frost Plug	Ν	⋈
Thermostat	+	✡

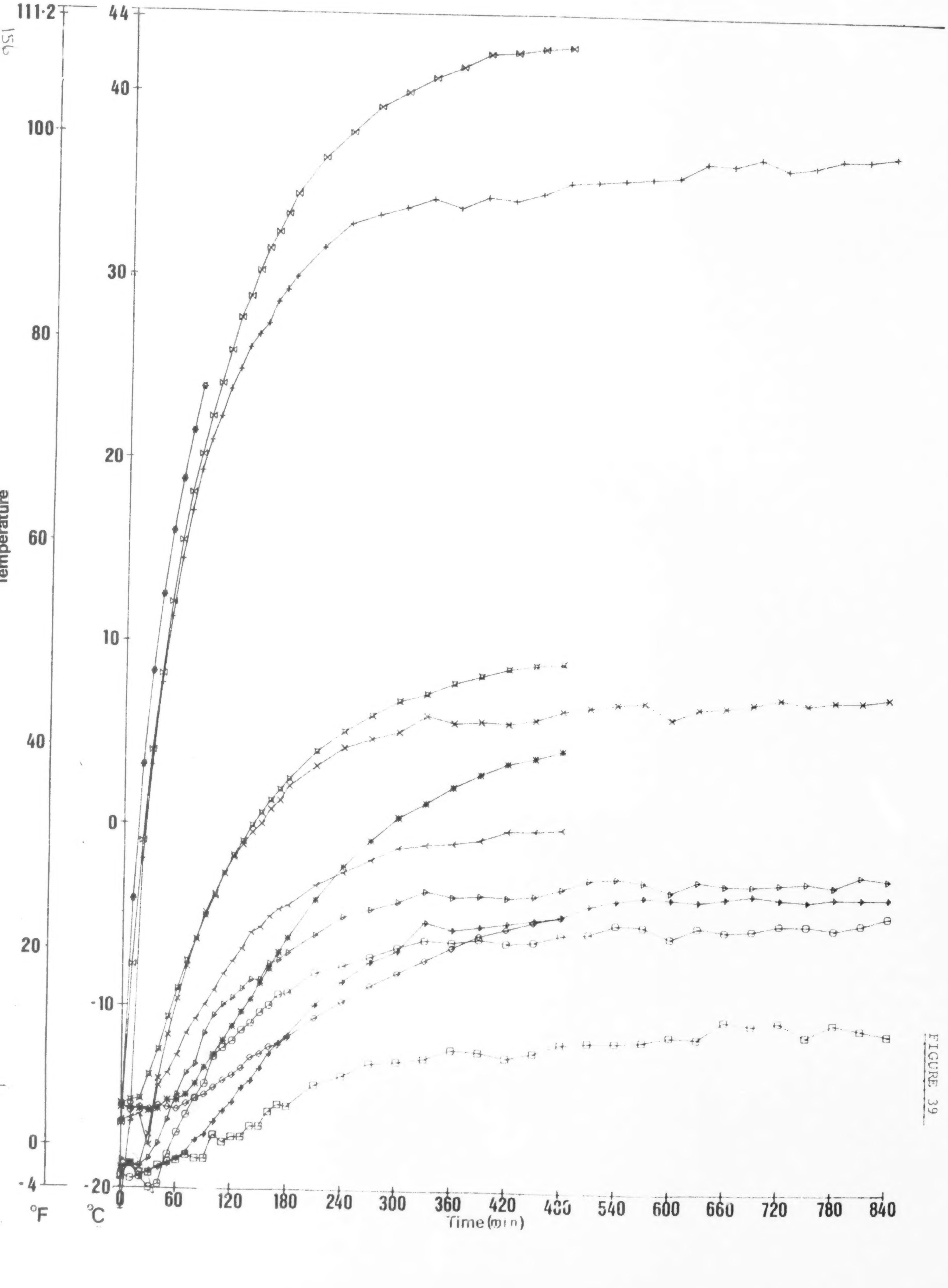


FIGURE 39

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

CITY CYCLE COLD TRANSIENT   FUEL CONSUMPTION COMPARISON TRACES

Vehicle Identification No (last six digits): 109222

Vehicle Number: 5 HIGH COMPRESSION

FUEL CONSUMPTION VERSUS TIME

(Base Car: 1980 1·7 L 'L' car w/ 1979 carb., ESA, dist. & EGR)

(test run with hood closed)

Sym.	Run	Test Temp. °C	Hardware Config.
⊟	5.1.2-1	25	Base
▷	5.1.3-1	0	"
+	5.1.4-1	- 20	"
×	5.2.2-1	25	w/High Compression - Chip #1
◇	5.2.3-3	0	" " "
✳	5.2.4-2	- 20	" " "
○	5.3.2-1	25	" " #12
⌽	5.3.3-3	0	" " "
≺	5.4.2-2	25	" " #2
⋈	5.4.3-2	0	" " "
Ν	5.4.4-2	- 20	" " "

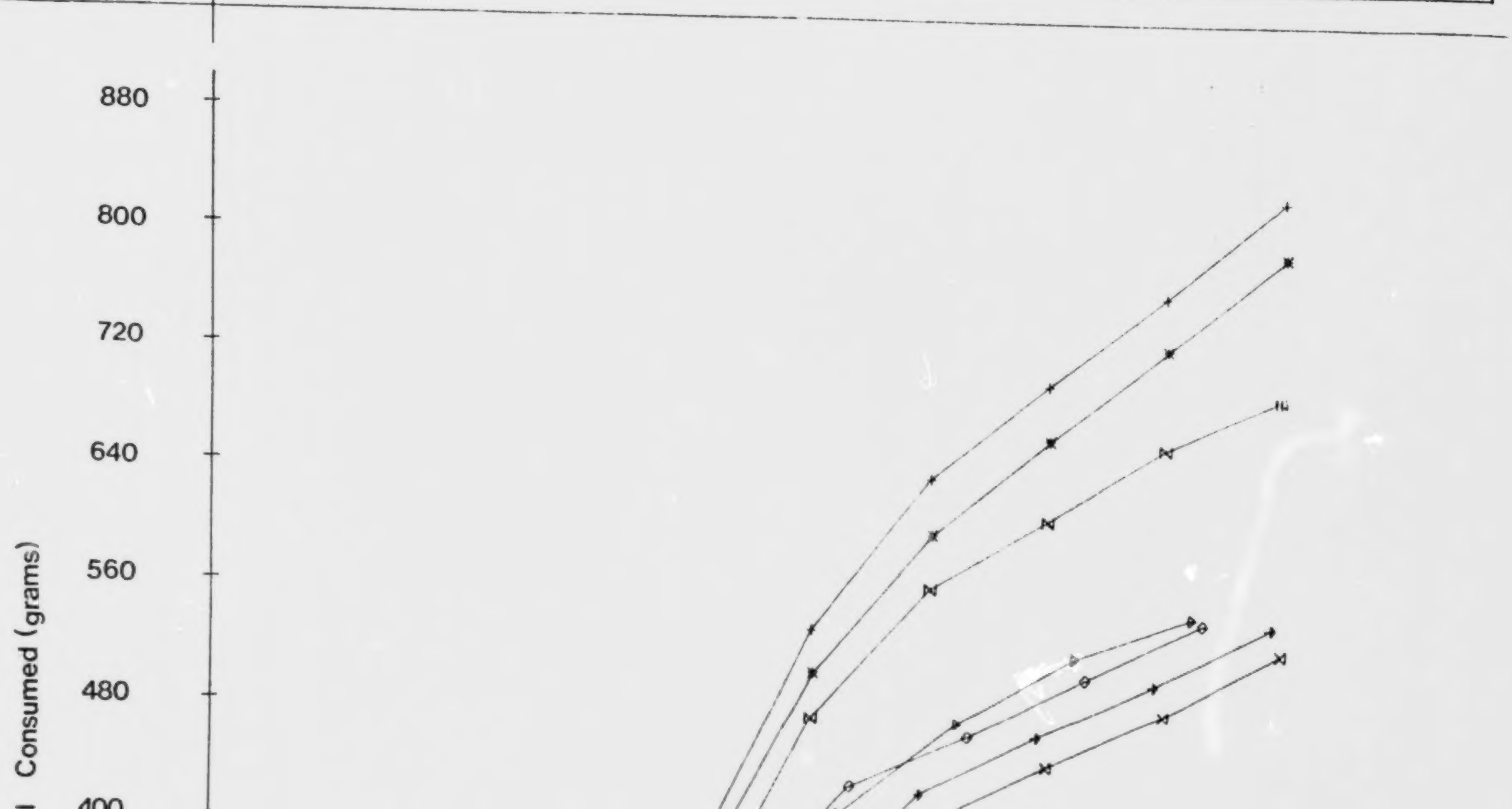
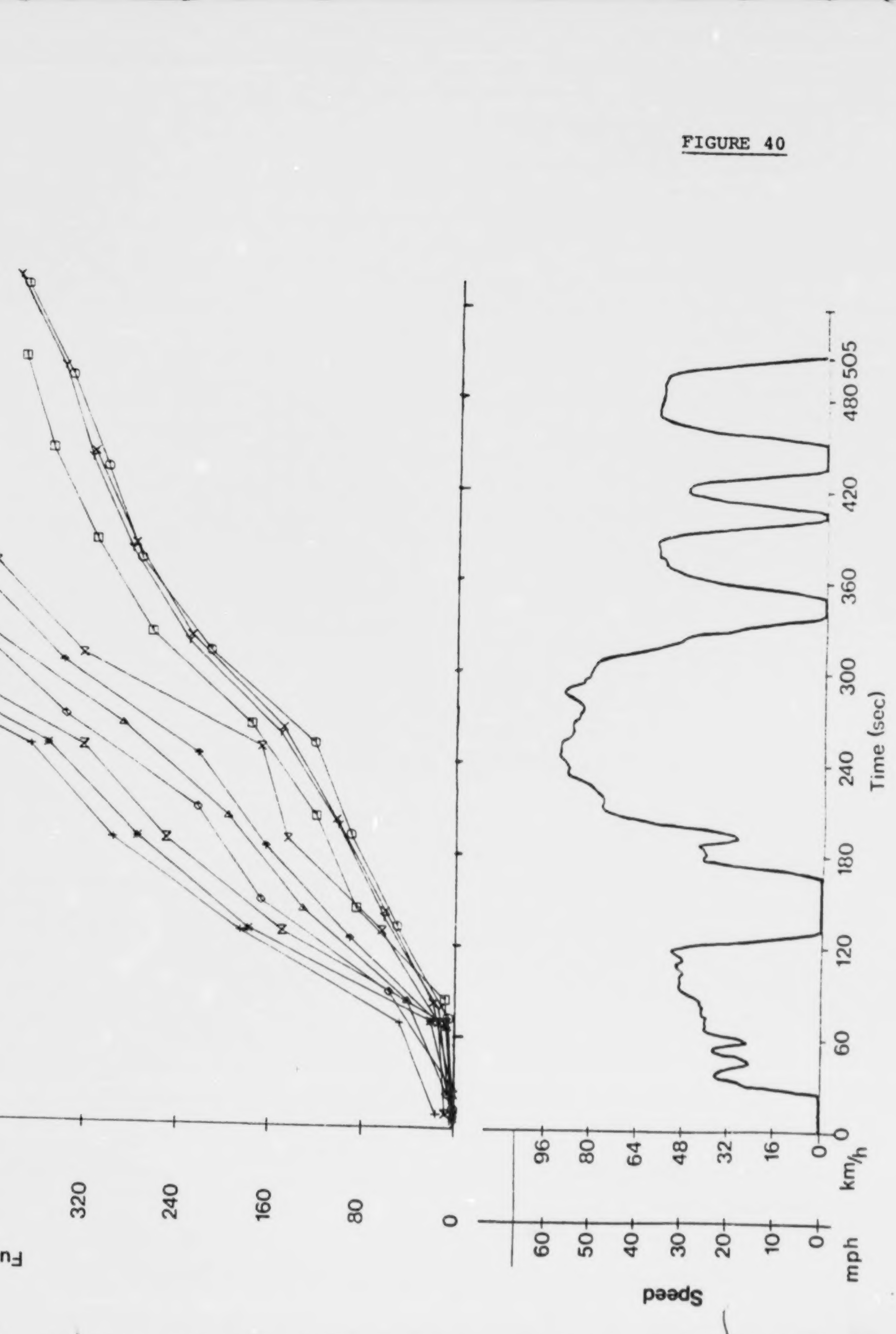


FIGURE 40


Fu
320
240
160
80
0
Speed
mph
0
10
20
30
40
50
60
km/h
0
16
32
48
64
80
96
0
60
120
180
240
300
360
420
480
505
Time (sec)

Volume

3

A FINAL REPORT TO TRANSPORT CANADA

EVALUATION OF POTENTIAL IMPROVEMENTS
IN AUTOMOBILE FUEL CONSUMPTION AT
LOW TEMPERATURES - PHASE I

VOLUME 3 - APPENDICES

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Prepared By:

DAVIS ENGINEERING LIMITED
CONSULTING ENGINEERS
OTTAWA, ONTARIO

September 1981

DE File No: C80-27

TC Contract No: OST80-00058

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Appendix 2	Cold Weather Program Scheduled Test Vehicle Maintenance Operations and Record
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Appendix 4	Basic Electrical (RLPC) Calibration Procedure
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Appendix 7	Transport Canada City Driving Cycle
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APPENDIX 1

Vehicle Driveability Evaluation Procedure

[redacted]

S.I.D. (START, IDLE, DRIVE) VEHICLE DRIVEABILITY EVALUATION PROCEDURE

Under the "S.I.D." vehicle driveability rating system, vehicles [redacted] are evaluated for several functions under various vehicle conditions.

FUNCTIONS:

- Engine Starting
- Idle Rating
- Car In Motion - Driveability
- Performance
- Spark Knock
- Stalls

CONDITIONS:

- Cold
- During Warm-Up
- Warmed-Up
- After Hot Soak
- After Partial Cool-Down.

A 1 to 9 (9 is best) numerical rating system is used for the rating functions. The rating number is intended to represent the driver satisfaction level. Table 1 defines the satisfaction levels in general terms. Tables 2, 3, 4 and 5 relate these same definitions to the Start, Idle, Drive and Performance respectively.

Downgrade for stalling is reflected in the appropriate S.I.D. function. Spark knock is noted separately from the drive evaluation.

I. STARTING

Vehicles are to be started in accordance with the procedure printed on Attachment 7. Starting performance is to be rated in accord with Table 2.

Die-outs and passouts occurring after a start, but before the car has been moved from the parking space, should be included in the starting rating by downgrading the potential starting rating in accordance with the severity of the condition experienced. A die-out is defined as an engine stall with the throttle in the closed position irrespective of vehicle movement.

Note: In cold starting a vehicle, the throttle is open to a fast idle cam position. It will be assumed that in this position, the throttle is closed since the throttle is against the designed stop.

A passout is an engine stall with throttle movement irrespective of vehicle movement. Downgrading of start due to stalls is in accordance with Table 2.

An asterisk (*) should be added to any rating which is downgraded for a stall.

A cold-start is defined as a vehicle which before being started, has been thoroughly warmed to normal operating condition, then soaked for a minimum of eight hours and a maximum of 18 hours. Three rating scales for different ambient temperature ranges are used (Table 2). Care must be exercised to use the correct rating scale for the appropriate temperature range.

A hot-start is one in which a fully warmed-up engine has soaked approximately .2 (12 min.) to .8 (48 min.) of an hour, dependent on ambient temperature. Hot-start is rated only above 10°C(50°F).

A partial cool-down (PCD) start is one in which the restart is applied to a vehicle fully warmed, after a soak of 1.5 to 4 hours. Both partial cool-down and hot start are illustrated graphically in Attachment 8. The importance of correctly noting soak time, ambient temperature and start time when starting vehicles is stressed.

II. IDLE

The idle quality will be rated using a 1 to 9 scale, with the vehicle in gear (except for manual transmission vehicles). On vehicles equipped with air conditioning, the idle quality should be noted both with A/C and without A/C operational. Idle ratings placed in the S.I.D. matrix are without A/C operational. Idle ratings will not be downgraded for stalls as done for start, since idle ratings of 1 thru 3 will define this condition. Idle quality is to be rated in accord with Table 3. An asterisk(*) should be used whenever a dieout occurs.

III. DRIVE

The drive evaluation is comprised of four distinct areas: Cold (during warm-up); Warm; Hot; and Partial Cool-Down (PCD). The cold drive is judged from the point when the vehicle is placed in gear, after the cold start, and begins to move to the point of temperature equilibrium. An indication of equilibrium in the coolant temperature gauge indicates the end of the cold period. Cold drive will be evaluated by a series of light

III. DRIVE (Cont'd.)

tip-ins (LTI), and heavy tip-ins (HTI) from rest, at one-tenth mile increments for the first mile, and two-tenth increments between one and three miles.

A fully warmed-up drive is the condition after the cold period is ended or when the engine has reached equilibrium. Warm drive is evaluated by driving the vehicle at various steady state speeds and acceleration modes from the steady state speeds indicated on the drive evaluation sheet. It should be noted that the acceleration modes during warm drive should not necessarily involve a downshift since this is evaluated in performance.

Hot drive is the portion of the evaluation which takes place after the fully warmed-up vehicle has soaked for a period of .2 (12 min.) to .8 (48 min.) of an hour. The vehicle is then started and driven away, utilizing a light tip-in. The drive evaluation should continue to temperature equilibrium. Ambient temperature must be above 10°C (50°F).

Partial cool-down (PCD) drive takes place after the fully warmed-up vehicle has soaked for a period of 1.5 to 4 hours. The vehicle is then started and driven away using a light tip-in. The drive rating includes all characteristics until the vehicle is warmed-up to equilibrium.

If the evaluator is uncertain of when temperature equilibrium occurs, the following guidelines may be used:

Hot Start	-	3 Minutes
Cold Starts Above 10°C (14°F)	-	10 Minutes
Partial Cool Down	-	10 Minutes
Cold Starts Below 10°C (14°F)	-	15 Minutes

The importance of comments in all aspects of the driveability evaluation is emphasized. Any peculiarities of the evaluation should be noted. Drive evaluation is to be rated in accord with Table 4. An asterisk (*) should be used whenever a dieout or passout occurs.

IV. PERFORMANCE

Performance rating is a relative indicator of how well the vehicle performs under heavy acceleration. Examples of performance evaluation would be WOT or nearly WOT acceleration from standing start, a high speed freeway traffic maneuver, or when merging into high speed freeway traffic from an entrance ramp. The rating must take into account which particular engine displacement/inertia weight/axle ratio combination is being evaluated. [redacted].

Since vehicle performance is difficult to measure accurately without the aid of stop watch, speedometer and test track, the subjective guidelines in Table 5 are to be used.

V. EXAMPLE

Following is an example of a completed evaluation matrix.

	COLD	WARM	HOT	PCD
START	5*	X	8	6
IDLE	6	5	5	3*
DRIVE	7	8	8	3*
PERFORMANCE	X	8	X	X

Cold Portion

The 5* rating represents a 3.0 second cold start time (above +20°F) with the rating downgraded 2 points for one die-out. The 6 idle rating represents idle quality with slight engine roughness and the 7 cold drive rating indicates driveability having one or more undesireable elements, but taking concentration to find.

Warm Portion

The 5 idle rating represents an irritating condition. A definite undesireable condition exists, but not to the extent that it is disturbing. The 8 driveability represents a trace of only one undesireable element that can be found. The 8 performance rating indicates a vehicle that under heavy acceleration, performs better than the customer would expect considering engine displacement/inertia weight/axle ratio combination.

Hot Portion

The 8 start represents a 1.1 to 2.0 second crank with no die-outs. The 5 idle rating would be the same as described in the warm section and the 8 drive would also be the same as in the warm section.

PCD

The 6 start represents a 3.1 to 4.0 second crank with no die-outs. The 3 idle rating indicates an idle that would give the evaluator lack of confidence. The vehicle had die-outs and extremely rough idle. The 3 drive represents a condition that undermines the driver's confidence in the car's ability to perform reliably at all times.

[redacted]

[redacted]

"ATTACHMENTS"

1. Rating Definitions in Terms of Customer Satisfaction.
2. Start Ratings.
3. Idle Ratings.
4. Drive Ratings.
5. Performance Ratings.
6. Glossary of Driveability Terms.
7. Starting Procedure.
8. Vehicle Cool-down Curve.

[redacted]

Table 1

"RATING DEFINITIONS IN TERMS OF CUSTOMER SATISFACTION"

9. Exceptional - No defects; driver is truly impressed.

8. No Significant Deficiencies - Only traces of deficiencies can be found; driver is pleased.

7. Minor Deficiencies - Few deficiencies, all minor in nature; driver is satisfied.

6. Obvious, But Not Objectionable Problems - A definite undesireable characteristic exists; however, the driver does not consider it objectionable. Driver is generally satisfied.

5. Marginal - Borderline, driver is not particularly happy with car operation, but is not likely to complain unless irritated for some other reason.

4. Disturbing - An owner would seek corrective action.

3. Lack of Confidence - Condition is so severe as to cause driver to loose confidence in the ability of the vehicle to perform reliably, though failure to perform is rare.

2. Unreliable - Periodic failure to perform.

1. Unpredictable - Erractic and uncontrollable failure to perform.

Table 2

"START RATING"

		RATING		
	START TIME	ALL STARTS EXCEPT COLD STARTS BELOW -8°C(20°F)	COLD STARTS BETWEEN -8°C + -18°C (20°F + 0°F)	COLD STARTS BETWEEN -18°C + -30°C (0°F + -20°F)
START TIME Time applies to either first start or any subsequent restart, whichever is the longest.	1.0 or Less	9	9	9
	1.1 - 2.0	8	9	9
	2.1 - 3.0	7	8	9
	3.1 - 4.0	6	8	8
	4.1 - 5.0	5	7	8
	5.1 - 6.0	4	6	7
	6.1 - 7.0	3	5	7
	7.1 -8.0	2	5	6
	8.1 -9.0	2	4	5
	9.1 -10.0	1	3	5
	10.1 - 12.0	0	2	4
	12.1 - 14.0	0	1	3
	14.1 - 15.0	0	0	1
	Over 15	0	0	0
	STALLS			
STALLING DOWNGRADE	1	2	1	1
	2	5	3	2
	3	6	5	3
	4 or More	7	7	1 per START

Table 3

"IDLE RATING"

RATING	DEFINITION
9	No trace of an undesireable element can be found and one cannot feel that the vehicle is running.
8	Engine operation is barely perceptible. Idle is totally smooth and flawless.
7	Engine vibration is noticeable but smooth and unobjectionable.
6	Consistent idle speed with slight engine roughness.
5	This would be an irritating condition, such as a moderately rough or pulsating idle.
4	Disturbing: An engine operation problem exists which is disturbing to the driver but is not serious enough to undermine the driver's confidence in the car's ability to continue running. An idle that causes severe driveline shock upon engagement or is very rough. This would be considered unacceptable.
3	Lack of Confidence: A condition exists which undermines the driver's confidence in the car's ability to perform reliably at all times. (Examples are extremely rough idle or decel die-outs after the vehicle comes to rest.)
2	Frequent die-outs.
1	Multiple die-outs, operation is erratic and uncontrollable.

Table 4

"DRIVE RATING"

RATING	DEFINITION
9	No trace of any undesireable element can be found and in addition, the car has exceptionally good responsive feel under all conditions.
8	Traces of undesireable elements can be found with extreme concentration or no undesireable characteristics but lacking the responsiveness and feel of a 9 rating.
7	One or more undesireable characteristics can be found, but take concentration to find. (Examples are light surge or off idle flatness.)
6	The undesireable characteristic(s) are definitely noticeable, but not objectionable. (Examples are moderate surge, sags, and/or stumbles.)
5	The undesireable characteristic(s) are obvious and somewhat irritating and may result in a customer complaint. (Examples are medium surge, sags, and/or stumbles.)
4	Disturbing: An engine operation exists which is disturbing to the driver but is not serious enough to undermine the driver's confidence in the car's ability to continue running. (Examples are heavy surge, sags, and/or stumbles.) The customer would definitely seek corrective action.
3	A condition exists which undermines the driver's confidence in the car's ability to perform reliably at all times. (Examples are severe surge, sags and/or stumbles.)
2	A failure of the engine to continue running. (Examples are passouts that could be driven around or decel die-outs which occur while the vehicle is still in motion.)
1	A condition exists which could cause unpredictable driveability during normal operations. This rating would generally apply to moving passouts which cannot be driven around.

PERFORMANCE

NO.	DEFINITION
9	The vehicle would have an exceptionally good responsive feel under all conditions.
8	Vehicle's performance is above average. Driver feels the car has better performance than he expected.
7	Driver feels vehicle's performance is what it should be.
6	Satisfactory: Driver feels vehicle does not perform as well as he thought it would but he would not return the car for a performance complaint.
5	Borderline: Vehicle does not perform as well as driver thought it would. A customer may complain and ask that the vehicle be checked for proper operation (e.g., poor passing and acceleration capability under normal conditions).
4	Disturbing: An engine performance problem exists which is disturbing but is not serious enough to undermine the driver's confidence in the car's ability to pass another vehicle. A customer would be unhappy with product and require that the condition be corrected.
3	Lack of Confidence: Vehicle performance is so weak that the driver lacks the confidence required to try a passing maneuver.
2	Vehicle performance is so weak that the driver is reluctant to operate vehicle on public roads.
1	Undefined

Table 6

GLOSSARY OF DRIVEABILITY TERMS

After Running:
Engine continues to run after the ignition is turned off. Sometimes referred to as "dieseling" although this is not an accurate description of the condition and After-Running is preferred.

Backfire:
Combustion of the unburned air-fuel mixture which takes place in the exhaust system rather than in the combustion chamber. Resulting combustion pressure exits through the muffler and tailpipe.

Detonation or Spark Knock:
Engine "knock" that occurs only when accelerating. Usually associated with medium to heavy throttle acceleration or lugging at relatively low speeds especially with a manual transmission. However, it may occur in higher speed ranges under heavy load conditions. Caused by advance timing or low octane fuel.

Die-Out:
An engine stall with the throttle in the closed position irrespective of vehicle movement.

Flat Spot:
Lack of normal acceleration or response to throttle opening ... no loss of power, but no increase. Engine does not miss or die as in the case of Cut-Out or Pass-Out.

Hesitation:
Momentary lack of throttle response at some car speed.

Miss:
Short for misfires or failure to ignite the mixture in one or more cylinders. This condition may be intermittent or continuous on one or more cylinders.

Pass-Out:
An engine stall with throttle movement irrespective of vehicle movement.

Pop-Back:
Mixture in the intake manifold is ignited and the resulting combustion takes place outside of the combustion chamber so that it may "pop-back" through the carburetor.

Sag:
Lack of normal acceleration or response to the initial movement of the throttle followed almost immediately by normal response. A sag is severe hesitation.

Stumble:
Lack of response to initial movement of the throttle from a standstill.

Table 6 (Cont'd.)

Surge:
Engine speed increases and decreases slightly but perceptibly in spite of the fact that the driver has not changed throttle position.

Vapor lock:
Slow hot start or won't start condition caused by vaporization of the fuel in the fuel lines. As a result, liquid fuel is not delivered to the carburetor.

TO START ENGINE

COLD ENGINE OR FIRST START OF DAY (Above 0°F)

Press accelerator pedal to floor and slowly remove foot from pedal. Turn key to "START" and hold until engine runs, then release key.

If engine speed seems excessive, lightly depress and release pedal five seconds after start.

WARM ENGINE

Press accelerator pedal 1/3 of the way down and hold. Turn key to "START" and hold until engine runs, they release key and pedal.

EXTREMELY COLD ENGINE (Below 0°F)

Press accelerator pedal to the floor and release. Then hold pedal 1/3 of the way down. Turn key to "START" and hold until engine runs, then release key and pedal.

IF ENGINE FAILS TO START

If engine fails to start after cranking for 15 seconds, stop cranking, and after one minute repeat the proper procedure.

If repeated starting attempts are unsuccessful, the engine may be "loaded" with gasoline. In this instance, the following procedure should be followed:

1. Press the accelerator pedal all the way to the floor and hold firmly. DO NOT PUMP THE PEDAL.
2. Turn key to "START".
3. Release key when engine starts.
4. Release pedal gradually as engine speeds up.

CAUTION: Do not hold key in "START" position longer than 15 seconds at a time.

CAUTION: Cold start difficulty can result if ignition is left in "ON" position when engine is not running.

CHRYSLER CORPORATION

Driveability Evaluation
Stamping and Assembly Division
Product Engineering

VIN

Engine Engine Sales Code

Transmission

Market Test Weight

Axle Air Pump/ASP

	Cold	Warm	Hot	PCD
Start		X		
Idle				
Drive				
Performance	X		X	X

1. Cold Start
Soak Time
Temperature
Start Time
Fast Idle
Kick Down
Die-Outs
Pass-Outs

2. Warm-Up
Idle Quality
- With A/C
- W/O A/C

0 Mile LTI
.1 Mile HTI
.2 Mile LTI
.3 Mile HTI
.4 Mile LTI
.6 Mile HTI
.8 Mile LTI
1.0 Mile HTI
1.2 Mile LTI
1.4 Mile HTI
1.6 Mile LTI
1.8 Mile HTI
2.0 Mile LTI
2.2 Mile HTI
2.4 Mile LTI
2.6 Mile HTI
2.8 Mile LTI
3.0 Mile HTI
Comments

3. Fully Warmed-Up
Idle Quality
- With A/C
- W/O A/C

30 MPH S.S.
ACCEL. 30-40
40 MPH S.S.
ACCEL. 40-55

Performance

Comments

4. Hot Start (Above 50° F)
Soak Time
Temperature
Start Time
Idle Quality
- With A/C
- W/O A/C

Die-Outs
Pass-Outs
Driveaway

Comments

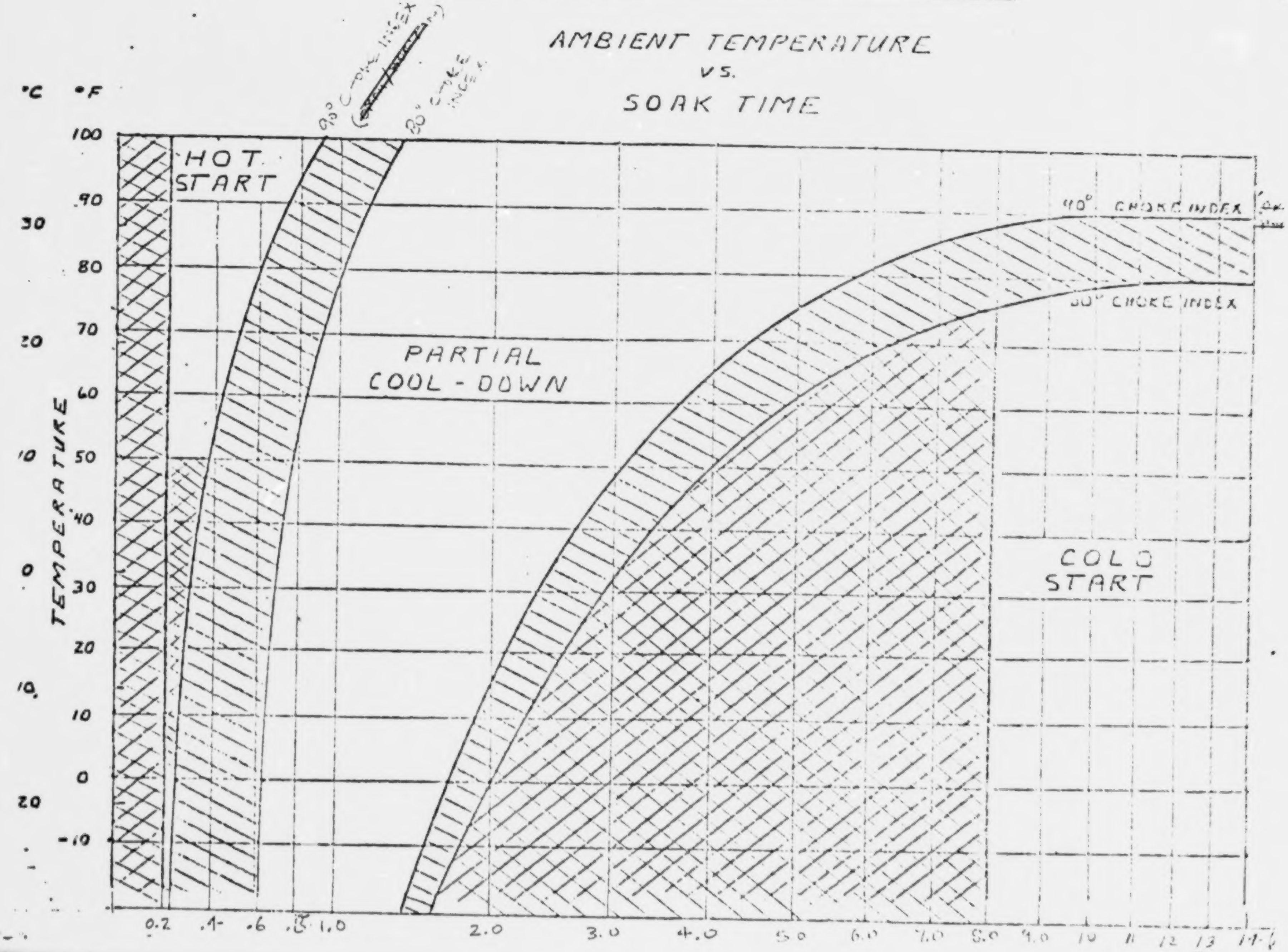
5. Partial Cooldown
Soak Time
Temperature
Start Time
Idle Quality
- With A/C
- W/O A/C

Die-Outs
Pass-Outs
Driveaway

ATTACHMENT VIII

DRIVEABILITY COOL-DOWN RATE

AMBIENT TEMPERATURE vs. SOAK TIME



DRIVEABILITY EVALUATION REPORT

DATE: ____________________ VEHICLE ID: ____________________

DRIVER: ____________________ TEST NO: ____________________

TEST ENGINEER: ____________________

S.I.D. RATING SUMMARY

	COLD	WARM	HOT	PCD
START		X		
IDLE				
DRIVE				
PERFORMANCE	X		X	X

COLD START

Time (Start of Soak) ____________________

Time (End of Soak) ____________________

Soak Time ____________________

Overnight Low (°C) ____________________

Start of Test Temp. (°C) ____________________

Barometer (kPa) ____________________

Relative Humidity ____________________

Stant Time (sec.) ______, ______, ______, ______

Die - Outs ____________________

Comments ____________________

WARM UP

	IDLE	COMMENTS	DRIVE	COMMENTS
0 Mile LT1				
.1 Mile MT1				
.2 Mile LT1				
.3 Mile HT1				
.4 Mile LT1				
.6 Mile HT1				
.8 Mile LT1				
1.0 Mile HT1				
1.2 Mile LT1				
1.4 Mile HT1				
1.6 Mile LT1				
1.8 Mile HT1				
2.0 Mile LT1				
2.2 Mile HT1				
2.4 Mile LT1				
2.6 Mile HT1				
2.8 Mile LT1				
3.0 Mile HT1				
OVERALL RATING				

NOTE: Continue driving vehicle until fully warmed up (i.e. stable coolant temperature)

FULLY WARMED UP

	RATING	COMMENTS
IDLE		
DRIVE ABILITY *		
50 KPH S.S		
ACCEL 50 - 65		
65 KPH S.S		
ACCEL 65 -90		
PERFORMANCE **		
ACCEL 0 - 65		
ACCEL 50 - 90		
ACCEL 80 - 100		

* Do not engage transmission downshifts in accels

** W.O.T. accels

RATING SUMMARY

IDLE	
DRIVE ABILITY	
PERFORMANCE	

HOT START

Soak Time ________________

Temperature (°C) ________________

Start Time (sec.) __________, __________, __________, __________

Die - Outs ________________

	IDLE	COMMENTS	DRIVE	COMMENTS
0 Mile LT1				
.1 Mile MT1				
.2 Mile LT1				
.3 Mile HT1				
.4 Mile LT1				
.6 Mile HT1				
.8 Mile LT1				
1.0 Mile HT1				
1.2 Mile LT1				
1.4 Mile HT1				
1.6 Mile LT1				
1.8 Mile HT1				
2.0 Mile LT1				
2.2 Mile HT1				
2.4 Mile LT1				
2.6 Mile HT1				
2.8 Mile LT1				
3.0 Mile HT1				
OVERALL RATING				

NOTE: Continue driving vehicle until fully warmed up (i.e. stable coolant temperature)

PARTIAL COOLDOWN

Soak Time ____________________

Temperature ('C) ____________________

Start Time (sec.) __________, __________, __________, __________

Die - Outs ____________________

	IDLE	COMMENTS	DRIVE	COMMENTS
0 Mile LT1				
.1 Mile MT1				
.2 Mile LT1				
.3 Mile HT1				
.4 Mile LT1				
.6 Mile HT1				
.8 Mile LT1				
1.0 Mile HT1				
1.2 Mile LT1				
1.4 Mile HT1				
1.6 Mile LT1				
1.8 Mile HT1				
2.0 Mile LT1				
2.2 Mile HT1				
2.4 Mile LT1				
2.6 Mile HT1				
2.8 Mile LT1				
3.0 Mile HT1				
OVERALL RATING				

NOTE: Continue driving vehicle until fully warmed up (i.e. stable coolant temperature)

APPENDIX 2

Cold Weather Program Scheduled Test Vehicle Maintenance Operations and Record

COLD WEATHER PROGRAM

Test Vehicle Maintenance Record

Vehicle I.D.__________ Date __________ Time__________ Odometer__________

Reason ____

____

SERVICE OPERATIONS	YES	NO	
Engine Oil Filter Changed	☐	☐	
Engine Oil Changed	☐	☐	_____1 of 10W30
	☐	☐	Gap 0.035"
Tire Condition	____	____	__________
Air Filter Cond	____	____	__________
Hoses, No. Leaks	____	____	__________

Other Maintenance:____

____

______________________ Technician

______________________ Project Engineer

COLD WEATHER PROGRAM

Test Vehicle Maintenance Record

Vehicle I.D.____________ Date ________________ Time__________ Odometer___________

Reason ____

____

SERVICE OPERATIONS	YES	NO	
Engine Oil Filter Changed	☐	☐	
Engine Oil Changed	☐	☐	_____ 1 of 10W30
Spark Plugs Changed	☐	☐	Gap 0.035"

SPECIFICATIONS AND ADJUSTMENTS*

	Transmission Dr.	Transmission N	Manufacturer's Specification	Before adjust.	After Adjust.
Ignition Timing		X	15°		
Idle RPM		X	900		
Idle Mixture (CO%)		X	NA		
HC ppm		X	NA		
Enriched RPM		X	1000		
Hot Fast Idle RPM		X	1700		
Throttle Stop Speed RPM		X	700		
Vacuum Kick			0.040"		
Choke Index			2 notches rich		
Fast Idle Cam index			0.040"		

*REFER TO SHOP MANUAL FOR PROPER PROCEDURES.

OPERATIONAL CHECKS	O.K.	Not O.K.	Remedial Action
Spark Plugs			
High Tension Wires			
EGR System			
AIR System			
Exhaust System Leaks			
Heated Inlet Air System			
Fuel System Leaks			
Throttle Free			
Brake Drag			
VISUAL CHECKS			
Engine Oil Level			
Trans Fluid Level			
Coolant Level			
Coolant Freezing Temp			
Battery Level			
Battery SG			
Belt Tightness			
Tire Condition			
Air Filter Cond			
Hoses, No. Leaks			

Other Maintenance:____

____

Technician

Project Engineer

MAINTENANCE RECORD CHANGES

For Configuration 2.2 and 2.3 - Vacuum Kick - .095"

For Configuration 4 - None

For Configuration 5.3 - Ignition Timing 22°

APPENDIX [illegible]

Road Load Power Control
Factory Calibration Procedure

R-6716 (012077)
(Rev. A) 042478

ROAD LOAD POWER CONTROL

FACTORY CALIBRATION PROCEDURE

CALIBRATION SEQUENCE:

A. Preliminary Set Up, Checks and Adjustment
B. EVW Selector Switch Range Verification
C. Board 7 - Thumbwheel Calibration
D. Board 6 - Pulser Calibration
E. Board 7 - Exponent Calibration
F. Board 8 - Horsepower Calibration
G. Board 5 - Analog Timer
H. Board 4 - Digital Timer
I. Board 8 - Rear Roll Speed Calibration
J. Board 7 - Front Roll Speed Calibration
K. Digital Speed Readout Calibration
L. Torque Load Cell Calibration
M. Digital Power Readout Calibration
N. Horsepower Scaling Verification
O. Horsepower "Cal Check" Operation
P. Deadband Adjustment
Q. Thumbwheel Adjustment
R. High Rate Deadband Adjustment
S. Driver Cutoff Adjustment
T. Exponent Verification
U. Load Control Speed Cutoff Verification
V. Manual Load Control Verification
W. Front-Rear/Vehicle Factor Verification
X. Horsepower Index Computer Interface Verification
Y. Final Preparations

A. Preliminary Set-Up, Checks and Adjustments:

1. Connect RLPC to "Dyno Simulator" (Simulator not connected to 115 VAC).
    a) Digital Instrument Box to Terminals 5, 6 and GND on Simulator.
    b) RLPC 6 TB, Terminals "H," "N" and GND.
    c) RLPC 1 TB, Terminals 201, 202, 206, 207, 208, 209, 210 and 211.
    d) RLPC 5 TB, Terminals 6, 93, 96, 97, 98 and "X."
    e) Digital Meter Box to RLPC 2 TB, Terminals 301, 302, 303 and 304.
2. Push down RLPC interlock switch.
3. Mode Selector Switch to "Pendant."
4. Speed-Power Switch to "Front."
5. Thumbwheel to 00.0 - Vehicle Factor to 0.00.
6. Turn Simulator RLPC 115 VAC Switch to "OFF."
7. Plug Simulator into 115 VAC.
8. Turn Simulator Digital Meter 115 VAC Switch to "ON."
9. Pot 1, Board 2 - Center.
10. Pot 2, Board 2 - Carefully center and seal.
11. Pot 3, Board 2 - Center.
12. Pot 1, Board 3 - Center.
13. Pot 2, Board 3 - Full CCW.
14. Pots 1 and 2, Board 4 - Full CCW.
15. Pot 3, Board 4 - Full CW.
16. Pots 1 and 2, Board 6 - Center.
17. Pot 3, Board 6 - Full CCW and seal.
18. Pots 4 and 5, Board 6 - Center.
19. Pot 6, Board 6 - Full CCW.
20. Pot 7, Board 6 - Full CCW and seal.
21. Pots 1, 2, 3, 4 and 5, Board 7 - Center.

22. IMPORTANT = Pot 9 (side pot), Board 7 - (Set for 52) - This is a 15-turn pot.

23. Turn all Cal Switches to "RUN" (toward the board).

24. Verify that all interconnect wiring is connected to RLPC terminal blocks properly:

    a) Upper Panel to Hat Section.
    b) EVW Selector Switch to 8 TB.
    c) Interlock Switch to 5 TB and 8 TB.
    d) Ground post to 5 TB.
    e) RLPC to Simulator.
    f) Digital Box to RLPC.
    g) Pendant to 5 TB.

25. Connect DVM (-) lead to RLPC "Common" terminal and leave connected for remainder of test. All following reference to DVM connection refers to (+) lead.

26. Turn Simulator RLPC 115 VAC switch to "ON" and pull RLPC interlock swtich "UP."

27. Check for (+) 15 VDC, ± 0.25 VDC, and (-) 15 VDC, ± 0.25 VDC, with DVM on Board 1 heat sink screws - if not within tolerance turn 115 VAC off and troubleshoot. Also check for ± 5.7 VDC on pins H and F on Board 1. Check for - 9.0 VDC on Terminal 312. Check for + 11.7 VDC on Terminal 207.

28. DVM to Test Point (TP) 5, Board 7.

29. Adjust Pot 6, Board 7, for 0.000 VDC, ± 0.002 VDC.

30. DVM to TP 2, Board 8.

31. Adjust Pot 3, Board 8, for 0.000 VDC, ± 0.002 VDC.

32. DVM to TP 1, Board 8.

33. Adjust Pot 1, Board 8 for 0.000 VDC, ± 0.002 VDC.

1. Verify that Range Light is on only in the range specified by the "A" number and is out when under or over range.

C. Board 7 - Thumbwheel Calibration:

PANEL SETUP

Thumbwheel - 00.0
All Switches to Run
Power Speed - Front
Mode - Pendant
Vehicle Factor - 00.0

1. DVM to Terminal 312, 2 TB.
2. Adjust Pot 1, Board 1, for (-) 9.000 VDC exactly.
3. DVM to TP 1, Board 7.
4. Adjust Pot 1, Board 7, for 0.000 VDC exactly.
5. DVM to TP2, Board 7.
6. Adjust Pot 2, Board 7, for 0.000 VDC exactly.
7. DVM to TP 3, Board 7.
8. Adjust Pot 3, Board 7, for 0.000 VDC exactly.
9. DVM to TP 4, Board 7.
10. Adjust Pot 1, Board 7, for 0.000 VDC exactly.
11. Verify exactly (-) 9.000 VDC on Terminal 312, 2 TB - if not, readjust Pot 1, Board 1, to correct.
12. DVM to TP 4, Board 7.
13. Thumbwheel to 00.9.
14. Adjust Pot 5, Board 7, for (+) 0.0900 VDC.
15. Verify that all positions of the 00.1 thumbwheel read corresponding VDC ± 0.0001 - Example, 00.6 thumbwheel position should read (+) 0.0600 VDC ± 0.0001.
16. Thumbwheel to 09.0.
17. Adjust Pot 4, Board7, for (+) 0.900 VDC.
18. Verify that all of the 01.0 thumbwheel positions read corresponding VDC ± 0.001 - example, 07.0 should read (+) 0.700 ± 0.001.
19. Thumbwheel to 10.0 DVM should read (+) 1.000 VDC ± .001.
20. Thumbwheel to 20.0 DVM should read (+) 2.000 VDC ± .001.

22. Seal Pots 2, 3, 4 and 5, Board 7.

D. Board 6 - Pulser Calibration:

PANEL SETUP

Thumbwheel - 30.0
All switches to Ru
Power Speed - Fron
Mode - Pendant
Vehicle Factor - 0

1. Connect Scope to "Common" of RLPC and

   TP 2, Board 6

   Scope set up Volts/CM = 5.0 Volts

   Time/CM = 0.1 Sec

2. Plug Simulator "Pulse Timer" probe into scope.

3. Press reset button on "Pulse Timer" - after timer stops counting (10 secs.), note pulse rate indicator.

4. Adjust Pot 4, Board 6, and repeat steps 3 and 4 until pulse rate is 22 to 25 pulses per 10 secons.

   CCW increases rate

   CW decreases rate

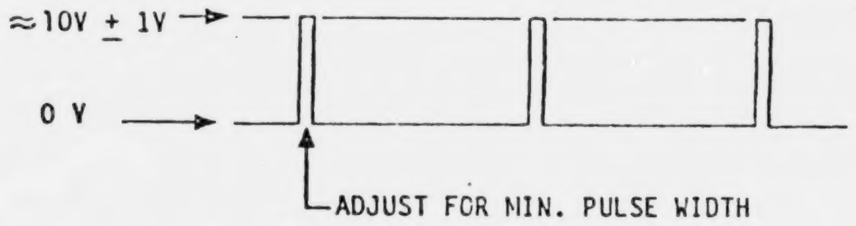
5. Recheck steps 3 through 5 - if within tolerance, seal Pot 4, Board 6.

6. Scope to TP 3, Board 6.

7. DVM to TP 1, Board 8.

8. Adjust Pot 1, Board 8, for DVM reading (+) 0.190 VDC ± 0.005.

9. Adjust Pot 1, Board 6, for scope pattern as shown.



10. Recheck steps 6 through 9 - if readjustment is unneccessary.

11. Adjust Pot 1, Board 8, for DVM reading of (+) 0.595 VDC, ± 0.005.

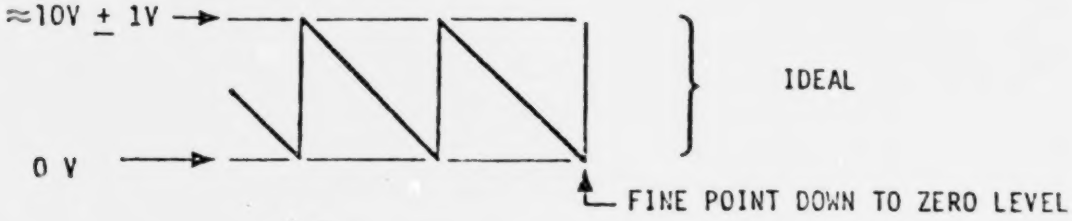
12. Slowly adjust Pot 6, Board 6, until square wave on scope JUST switches to a saw tooth.

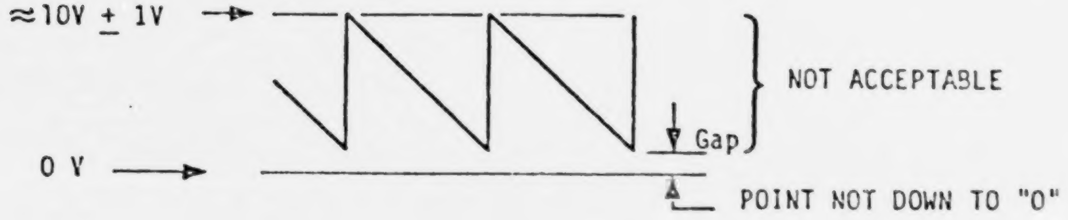
13. Adjust Pot 1, Board 8, for DVM reading of (+) 0.500 VDC, ± 0.010.

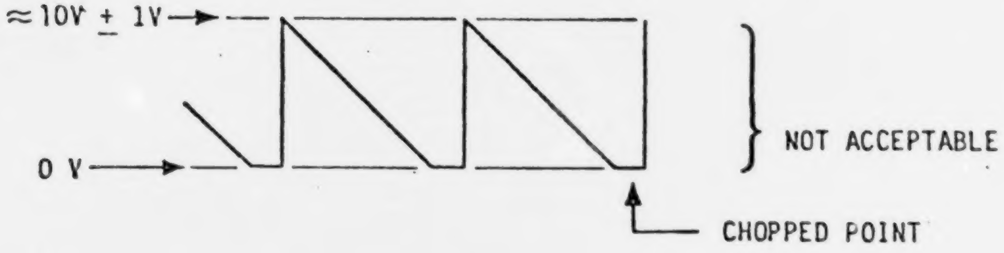
14. Slowly adjust Pot 1, Board 8, CCW until square wave JUSTswitches to a saw tooth - DVM reading should be (=) 0.595 VDC, ± 0.005 - if not, repeat steps 11 through 14.

15. Using "Pulse Timer" adjust Pot 5, Board 6, until saw tooth pulse rate is 22 to 25 pulses in 10 seconds.

16. Adjust Pot 2, Board 6, for a scope wave shape shown below as "IDEAL."


≈10V ± 1V
0 V
IDEAL
FINE POINT DOWN TO ZERO LEVEL


≈10V ± 1V
0 V
NOT ACCEPTABLE
Gap
POINT NOT DOWN TO "O"


≈10V ± 1V
0 V
NOT ACCEPTABLE
CHOPPED POINT

17. Seal Pot 2. Board 6.

18. Adjust Pot 1, Board 8, for 0.00 on DVM.

E. Exponent Calibration:

PANEL SETUP

Thumbwheel - 39.9
All Switches to Cal
Power Speed - Front
Mode - Pendant
Vehicle Factor - 0.

1. DVM to TP 5, Board 7.
2. Adjust Pot 5, Board 8, for DVM reading of (+) 6.000 VDC.
3. DVM to TP 6, Board 7.
4. Note and record DVM reading
5. DVM to TP 5, Board 7.
6. Adjust Pot 5, Board 8, for DVM reading of (+) 2.500 VDC.
7. DVM to TP 6, Board 7.
8. Note DVM reading.
9. DVM reading should be $\frac{(25)^2}{(60)}$ = .1736 X DVM reading recorded in Step 4.
10. Adjust Pot 9, Board 7 (side pot), to a DVM reading .005 higher than the required DVM reading of step 9 and the DVM reading noted in step 8 - read below note before making any adjust of Pot 9.

    NOTE: If the DVM reading noted in step 8 is HIGH, turn Pot 9 CW; if LOW Pot 9 CCW.

    If the difference between the DVM reading of step 8 and the required reading of step 9 is 0.002 or less, adjust Pot 9 to the required reading of step 9.

11: Repeat steps 1 through 12 until the DVM reading noted in step 8 is equal to the required reading of step 9 ± 0.003 VDC without any adjustment of Pot 9.

12. Repeat steps 1 through 5.
13. Adjust Pot 5, Board 8, for DVM reading of + 5.00 VDC.
14. DVM to TP 6, Board 7.

15. DVM reading should be $(\frac{50}{60})^2$ = .69444 X DVM reading of step 4 ± 0.002 VDC.

NOTE: If the noted reading is not within the 0.003 tolerance, repeat complete calibration of the Exponent and correct as necessary - if calibration does not correct the error, advise Engineering.

F. Board 8 - Horsepower Calibration:

PANEL SETUP

Thumbwheel - 39.9
Switches to Cal
Power Speed - Front
Mode - Pendant
Vehicle Factor - 0.

1. DVM to TP 2, Board 8.
2. Adjust Pot 5, Board 8, for DVM reading of (+) 5.000 VDC.
3. DVM to TP 1, Board 8.
4. Adjust Pot 6, Board 8, for DVM reading of (+) 5.000 VDC.
5. DVM to TP 4, Board 8.
6. Adjust Pot 7, Board 8, for DVM reading of (+) 2.500 VDC ± 0.001.
7. Recheck complete calibration correcting as necessary.
8. When calibration is within tolerance, seal Pot 7, Board 8.

G. Board 5 - Analog Timer:

PANEL SETUP

Thumbwheel - 07.0
All Switches to Cal
Power Speed - Front
Model - Pendant
Vehicle Factor - 0.

1. DVM to TP 2, Board 5
2. Note DVM reading - should be between (+) 1.00 and (+) 1.10 VDC - if not, recheck "Thumbwheel" calibration - [illegible]

   RECORD NOTED DVM READING
3. Thumbwheel setting 37.0.
4. Note DVM reading - should be between (+) 5.5 and (+) 5.6 VDC - if not, recheck "Thumbwheel" calibration -

   RECORD NOTED DVM READING [illegible]

5. Thumbwheel setting 07.0.

6. DVM to TP 6, Board 5.

7. Adjust Pot 2, Board 5, for DVM reading recorded at step 2 excetp (-) VDC.

8. Thumbwheel setting 37.0.

9. Adjust Pot 1, Board 5, for DVM reading recorded at step 4 except (-) VDC.

10. Recheck stpes 5 through 10 as many times as required, readjusting as necessary, until the required (-) VDC readings of step 7 (07.0 Thumbwheel) and step 9 (37.0 Thumbwheel) are obtained without further adjustments of Pots 1 and 2 when Thumbwheel is changed from one setting to the other.

11. Sel Pots 1 and 2, Board 5.

12. Compute the DVM readings recorded at steps 2 and 4 per the following: $-\sqrt{(10)\ \text{DVM reading}}$ (this will always be a (-) VDC). Record the computed VDC.

13. DVM to TP 3, Board 5.

14. Thumbwheel setting 07.0.

15. Adjust Pot 4, Board 5, for DVM reading computed at step 12 for recorded DVM reading of step 2 - Tolerance ± 0.003 VDC.

16. Thumbwheel setting 37.0.

17. Adjust Pot 3, Board 5, for DVM reading computed at step 12 for recorded DVM reading of step 4 - Tolerance ± 0.003 VDC.

18. Set Thumbwheel back and forth at 07.0 to 37.0 as many times as necessary making the adjustments of step 15 for 0.70 setting and step 20 for 37.0 setting until computed VDC is obtained without adjustment at either setting.

19. DVM to TP 5, Board 5.

20. Repeat steps 14 through 18 EXCEPT

    a) Use Pot 6 instead of Pot 4 in step 15.

    b) Use Pot 7 instead of Pot 3 in step 17.

21. DVM to TP 4, Board 5.

22. Thumbwheel setting 39.0.

23. Adjust Pot 5, Board 5, for DVM reading of 0.000 VDC ± 0.001.

24. DVM to TP 8, Board 5.

25. Adjust Pot 8, Board 5, for DVM reading of 0.000 VDC, ± 0.001.

H. Board 4 - Digital Timer:

PANEL SETUP

Thumbwheel - 5.00
All Switches to Run
Mode - Thumbwheel
Power Speed - Front
Vehicle Factor - 0.

1. Press "Index Light" and while light is flashing, change Thumbwheel to 35.0.

2. "Low Rate Load" light will come on approximately 10 seconds after "Index Light" is pressed - time the duration that load light is on.

3. Adjust Pot 1, Board 4, and repeat steps 1 and 2 until direction of load light is on 6.0 seconds.

    CW increases time.

    CCW decreases time.

4. Thumbwheel to 35.0.

5. Press "Index Light" and while light is flashing, change Thumbwheel to 05.0.

6. "Low Rate Unload" light will come on approximately 10 seconds after "Index Light" is pressed - time the duration that Unload light is on.

7. Adjust Pot 2, Board 4, and repeat steps 4 through 6 until duration of Unload light on is 9.0 seconds.

    CS increases time.

    CCW decreases time.

8. Make random changes of the Thumbwheel setting, increasing and decreasing, large and small changes throughout the range and check for operation of the timer system.
    a) The smaller the change, the shorter the load or unload light duration.
    b) Increase in setting should always turn on load light.
    c) Decrease in setting should always turn on unload light.
    d) Load and unload lights should never both come on.
    e) Duration that load or unload light is on should not exceed 1.0 second when Thumbwheel setting is changed by 01.0.
    f) Load or unload valves should not chatter during "ON" cycle.
9. Press "Index Light" and time duration that Index Light flashes.
10. Adjust Pot 3, Board 4, and repeat step 10 until the "Index Light" flashes for 30 seconds ± 2 seconds.

    CCW increases time.

    CW decreases time.

I. Rear Roll Speed Calibration:

1. DVM to TP 2, Board 8 323 4T6
2. With generator motor stopped, adjust t 3, Board 8, to obtain a DVM reading of 0.000 ± .002 VDC.
3. Turn generator motor on.
4. Adjust Pot 4, Board 8, to obtain a DVM reading of (+) ~~4.500~~ 4 65C VDC ± .002.

PANEL SETUP

Thumbwheel - 02.0
All Switches to Ru
Mode - Pendant
Speed Power - Rear
Vehicle Factor - C

NOTE: If any correction of the 0.000 reading is required to stay within tolerance, repeat steps 2, 3, 4 and 5.

6. Stop generator motor.

J. Front Roll Speed Calibration:

PANEL SETUP

Thumbwheel - 02.0
All Switches to Run
Power Speed - Front
Mode - Pendant
Vehicle Factor - 0.

1. DVM to TP 5, Board 7. 324 4 [illegible] TB
2. With the generator motor stopped, adjust Pot 6, Board 7, to obtain a DVM reading of 0.000 V ± .002 VDC.
3. Start generator motor.
4. Adjust Pot 7, Board 7, to obtain a DVM reading of 4.300 VDC ± 0.002. 4.632
5. Stop generator motor and recheck step 2 above.

   NOTE: If any correction of the 0.000 reading is required to stay within tolerance, repeat steps 2, 3, 4 and 5.
6. Stop generator motor.

K. Digital Speed Readout Calibration:

PANEL SETUP

Thumbwheel - 02.0
All Switches to Cal
Mode - Pendant
Speed Power - Front
Vehicle Factor - 0.

1. DVM to TP 2, Board 8.
2. Adjust Pot 5, Board 8, to obtain a DVM reading of 5.000 V ± .002 VDC.
3. Adjust speed span pot located under the Clayton logo on the instrument box to obtain a reading of 50.0 MPH (80.5 k/hr) on the digital speed meter

Thumbwheel - 02.0
All Switches to Run
Mode - Pendant
Speed Power - Front
Vehicle Power - 0.0

1. DVM to TP 4, Board 8, and record DVM Reading including (+) or (-) sign.
2. Set Switch 2, Board 8, to the "Cal"
   1, board 7,
   position (away from board).
3. Adjust Pot 5, Baord 8, to obtain a 50.0 MPH (80.5 k/hr) reading on the digital speed meter.
4. DVM to TP 1, Board 8.
5. Turn on generator motor to vibrate load cell system.
6. Adjust Pot 1, Board 8, to obtain a DVM reading of + .050 V ± 0.005 VDC.
7. DVM to TP 4, Board 8.
8. Slowly adjust Pot 1, Board 8, clockwise until DVM reading Just reaches the EVM reading recorded in step 1 above.

   CAUTION: Do not turn the pot more than is absolutely necessary to just reach the desired DVM reading.
9. DVM to TP 1, Board 8, and record this reading for use in steps L-14, S-5 and U-7 of the Calibration Procedure.
10. Install deadweight calibration hook and pan onto the torque arm.
11. ~~Gently~~ install three 35-pound weights onto the hook and pan.
12. Adjust Pot 2, Board 8, to obtain a DVM reading of 4.07 V ± .002 VDC.

14. Compare DVM reading with reading obtained in step 9 - if not the same, within ± 0.002 VDC, adjust Pot 1, Board 8, to correct, and repeat steps 10 through 14.

M. Digital Power Readout Calibration:

PANEL SETUP

Thumbwheel - 02.0
All Switches to Run
Mode - Pendant
Power Speed - Front
Vehicle Factor - 0.

1. Stop the generator motor.
2. Remove the instrument box cover.
3. Adjust the digital power meter to obtain a reading of 00.0 - adjust screw is accessible through the lower slot on the rear left side of the meter case - replace cover on instrument box.
4. Set Switches 1 and 2, Board 8, to the "Cal" position (away from board).
   2 board 7 to cal
5. Adjust Pot 5 on Board 8 to obtain a 50.0 MPH (80.5 k/hr) reading on the digital speed meter. TP 2 Board 8
6. DVM to TP 1, Board 8.
7. Adjust Pot 6, Board 8, to obtain a DVM reading of (+) 4.070 V ± 0.002 VDC.
8. Adjust the power span pot located under the Clayton logo on the instrument box to obtain a reading of 40.7.

N. Horsepower Scaling Verification:

PANEL SETUP

Thumbwheel - 02.0
Sw 2 Bd 8 - Cal
Sw 1 Bd 7 - Run
Mode - Pendant
Power Speed - Front
Vehicle Factor - 0.0

1. Set Switch 1, Board 8, to "Run" position (toward the board).
2. Adjust Pot 5, Board 8, as necessary to obtain a 50.0 MPH (80.5 k/hr) readout on the digital speed meter.
3. Turn on generator motor - place weights on the torque arm and check that horsepower readout is within tolerance of the table following:

None	0.0 ± 0.1 HP
Hook and Pan	1.9 ± 0.1 HP
Hook and Pan + 5 lbs.	14.8 ± 0.1 HP
Hook and Pan + 10 lbs.	27.8 ± 0.1 HP
Hook and Pan + 15 lbs.	40.7 ± 0.1 HP

4. Repeat paragraphs 1 and M as necessary for corrections.

O. Horsepower "Cal Check" Button Calibration:

1. Adjust Pot 5, Board 8, to obtain a reading of 50.0 MPH (80.5 k/hr) on the digital speed meter.
2. Press the "Cal Check" button and record the power reading - this reading is the "Cal Check" number - Should be 22.3 + 00.1.

PANEL SETUP

Thumbwheel - 02.0
Sw 1 Bd 8 - Run
Sw 1 Bd 7 - ~~Run~~ Cal
Sw 2 Bd 8 - Cal
Mode - Pendant
Speed Power - Front
Vehicle Factor - 0.0

P. Deadband Adjustment:

1. Adjust Pot 5, Board 8, to obtain 50.0 MPH (80.5 k/hr) on the digital speed meter.
2. Adjust Pot 6, Board 8, until the digital power meter reads 30.0 HP.
3. Adjust Pot 8, Board 7, until the dead band is centered around 30.0 HP.
4. Adjust Pot 6, Board 8, until all the load and unload lights go out (center of deadband).
5. Adjust Pot 6, Board 8, clockwise until the low rate load light juststarts to pulse - record the power reading.
6. The difference between the readings of 3 and 4 is the deadband.
7. Adjust Pot 3, Board 2, and repeat steps 3 and 4 until the difference between 3 and 4 (deadband) is equal to 0.4 horsepower.

PANEL SETUP

Thumbwheel - 30.0
Sw 1 & 2 Bd 8 to Cal
Sw 1 Bd 7 - Cal
Mode - Thumbwheel
Speed Power - Front
Vehicle Factor - 0.0

Q. Thumbwheel Adjustment:

I. THUMBWHEEL - LOW RANGE:

PANEL SETUP

Thumbwheel - 03.0
Sw 1 & 2 Bd 8 to Ca
Sw 1 Bd 7 to Cal
Mode - Thumbwheel
Power Speed - Front
Vehicle Factor - 0.

1. Adjust Pot 5, Board 8, to obtain a reading of 50 MPH (80.5 k/hr) on the digital speed meter.
2. Adjust Pot 6, Board 8, to obtain a reading of 3.0 HP on the digital power meter.
3. Adjust Pot 1, Board 7, until low and high rate load and unload lights go out.
4. Adjust Pot 6, Board 8, counterclockwise until the low unload light just starts to pulse - record the power reading.
5. Adjust Pot 6, Board 8, clockwise until the low light just starts to pulse - record the power reading.
6. Adjust Pot 1, Board 7, until the difference between 4 and 5 is centered around the 3.0 HP (load light just starts to pulse at 2.8 HP and unload light just starts to pulse at 3.2 HP).

II. THUMBWHEEL SPAN ADJUSTMENT:

Set "Thumbwheel Span" as follows:

1. DVM to Terminal 312, 2 TB.
2. Adjust Pot 1, Board 1, for DVM reading of (-) 9.000 VDC exactly.
3. Set the "Thumbwheel" to read 39.0.
4. Set Switches 1 and 2, Board 8, and Switch 1, Board 7, to the "Cal" position (away from board).
5. Adjust Pot 5, Board 8, to obtain a reading of 50.0 MPH (80.5 k/hr) on the digital speed meter.

digital power meter.

7. Adjust Pot 8, Board 7, until low and high rate load and unload lights go out.

8. Adjust Pot 6, Board 8, counterclockwise until the low unload light just starts to pulse - record power meter reading.

9. Adjust Pot 6, Board 8, clockwise until the low load light just starts to pulse - record power meter reading.

10. Adjust Pot 8, Board 7, until the readings of steps 8 and 9 are equally centered around 39.0 HP (load light just pulses at 38.8 and unload light just pulses at 39.2 HP).

11. IMPORTANT - Repeat parts I and II as many times as necessary until the Thumbwheel can be set for 03.0 and 39.0 and the "deadband" of 00.4 is centered at both settings without any adjustment of Pots 1 or 8, Board 7. Be sure the 50.0 MPH setting is maintained.

F. High Rate Deadband Adjustment:

PANEL SETUP

Thumbwheel - 39.0
Sw 1 & 2 Bd 8 to Cal
Sw 1 Bd 7 to Cal
Mode - Thumbwheel
Power Speed - Front
Vehicle Factor - 0.0

1. Adjust Pot 5, Board 8, to obtain a reading of 50 MPH (80.5 k/hr) on the digital speed meter.
2. Adjust Pot 6, Baord 8, for a reading of 40.5 on the power meter.
3. Adjust Pot 1, Board 3, until the high rate unload light just comes on.
4. Adjust Pot 6, Board 8, for a reading of 37.5 on the power meter.
5. Adjust Pot 1, Board 2, until the high rate load light just comes on.

S. Driver Cutoff Adjustment:

PANEL SETUP

Thumbwheel - 00.0
Sw 1 & 2 Bd 8 to Run
Sw 1 Bd 7 to Run
Mode - Thumbwheel
Power Speed - Front
Vehicle Factor - 0.0

1. DVM to TP 1, Board 8.
2. Adjust Pot 1, Board 8, to obtain a DVM reading of + 0.060 V ± .005 VDC.

unload lights just go out.

4. Turn on generator motor to vibrate load cell system.
5. Adjust Pot 1, Board 8, to obtain the same DVM reading as recorded in paragraph L-9.
6. Turn off generator motor.

T. Exponent Verification:

PANEL SETUP

Thumbwheel - 32.0
Bd 7 & 8 Sw to Cal
Mode - Thumbwheel
Power Switch - Front
Vehicle Factor - 0.0

1. DVM to TP 2, Board 8.
2. Adjust Pot 5, Board 8, for DVM reading of (+) 5.000 VDC ± 0.001.
3. Set Thumbwheel to 32.0
4. Adjust Pot 6, Board 8, for 32.0 HP on digital meter.
5. Using Pot 6, Board 8, check that "Deadband" is 0.40 and is centered about 32.0 - if not, recheck Thumbwheel Calibration, paragraphs Q-I and II, and repeat paragraph T.
6. Reset Pot 6, Board 8, for 32.0 HP on digital meter.
7. Adjust Pot 5, Board 8, for a DVM reading of 2.500 VDC ± 0.001.
8. Horsepower reading should be 16.0 - if not, recheck the Horsepower Calibration, paragraphs L, M and N, and repeat paragraph T.
9. Adjust Pot 6, Board 8, for 4.0 HP on digital meter.
10. Using Pot 6, Board 8, check that "Deadband" is centered about 4.0 HP ± 0.05 and that "Deadband" is less than 00.4 HP (deadband should be approximately 00.2) - if not, recheck Exponent Calibration and repeat paragraph T.
11. If ok, set Thumbwheel to 16.0.
12. Adjust Pot 6, Board 8, for 2 HP, check "Deadband" for 0.2 HP wide.
13. Adjust Pot 6, Board 8, for 8.0 HP on digital meter.
14. Adjust Pot 5, Board 8, for 5.000 VDC. Power Meter should read 16.0 HP.
15. Check "Deadband" at 16 HP, should be 0.4 wide.

U. Load Control Speed Cutoff Verification:

1. DVM to TP 1, Board 8.
2. Adjust Pot 1, Board 8, for (-) 0.050 VDC ± 0.005.
3. Adjust Pot 5, Board 8, for 10 MPH on digital meter - load light should be on.
4. Using Pot 5, Board 8, decrease MPH slowly and note MPH that all load lights go out-- should be between 3 and 5 MPH.
5. Using Pot 5, Board 8, increase MPH slowly and note MPH that load light comes on - should be between 4 and 6 MPH.
6. Turn on generator motor to vibrate load cell system.
7. Adjust Pot 1, Board 8, for same DVM reading recorded in paragraph L-9.
8. Turn off generator motor.

PANEL SETUP

Thumbwheel - 39.0
Sw 1 Bd 8 to Run
Sw 2 Bd 8 to Cal
Sw 1 Bd 7 to Cal
Mode - Thumbwheel
Power Speed - Front
Vehicle Factor - 0.

V. Manual Load Control Verification:

1. Bleed valve light of Simulator should be on.
2. Press Pendant unload button and verify that the low rate unload light of the RLPC comes on, and the bleed valve light of the Simulator goes out.
3. Press Pendant load button and verify that the low rate load light of the RLPC comes on, and the bleed valve light of the Simulator goes out.
4. Verify that the bleed valve light is not on when Mode Selector is in the Thumbwheel or Computer position and the Pendant is not functional.

PANEL SETUP

Thumbwheel - 00.0
All Switches to Run
Mode - Pendant
Power Speed - Front
Vehicle Factor - 0.

W. Front-Rear/Vehicle Factor Verification:

1. DVM to TP 1, Board 8.
2. Turn generator motor on.
3. Adjust Pot 6, Board 8, until all load/unload lights are out (this puts control in the center of the deadband).
4. Increase vehicle factor adjustment until high rate load light pulses then turns on full.
5. Turn off motor.

PANEL SETUP

Thumbwheel - 39.0
Sw 1 Bd 8 to Cal
Sw 2 Bd 8 to Run
Sw 1 Bd 7 to Run
Mode - Thumbwheel
Power Speed - Rear
Vehicle Factor - 0.

X. Horsepower Index Computer Interface Verification:

PANEL SETUP

Thumbwheel - 30.0
All Switches - Run
Power Speed - "Fron
Mode - "Thumbwheel"
Vehicle Factor - 0.

1. DVM to Terminal 320 on 3 TB.
2. Note that DVM reads 0.00 VDC.
3. Mode Selector to "Computer."
4. Note that DVM reads + 15 +.25 VDC.
5. Turn Power OFF!
6. Connect Ohmmeter to Terminals 317 and 318.
7. Note that there is continuity.
8. Mode Selector to "Thumbwheel."
9. Note that Ohmmeter reads "Open Circuit."

Y. Final Preparation:

1. Turn RLPC and digital meter 115 VAC OFF at Dynamometer Simulator and unplug Simulator from 115 VAC.
2. Check that all following Pots have been SEALED:

Pot 2	Board 2
Pots 1, 2 and 3	Board 4
Pots 1 through 8	Board 5
Pots 1 through 7	Board 6
Pots 2, 3, 4, 5, 8 and 9	Board 7
Pot 7	Board 8

3. Disconnect Dynamometer Simulator, Scope and DVM from RLPC.
4. Thumbwheel 02.0 - Vehicle factor 0.00 - Speed Power Front - Mode Pendant.
5. Set 7 and 8 Board Switches to "Run."
6. Check to be sure all Terminal Board screws are tight.
7. Secure all covers.

DRIVER CUTOFF ADJUSTMENT:

Thumbwheel - 00.0
Sw 1 & 2 Bd 8 to Cal.
Sw 1 Bd 7 to Run
Mode - Thumbwheel
Power Speed - Front
Vehicle Factor - 0.00

1. DVM to TP1, Board 8

2. Adjust Pot 6, Board 8, to obtain a DVM reading of + 0.060 ± .005 VDC

3. Adjust Pot 2, Board 3, until both the low and high rate unload lights just go out

4. Adjust Pot 6, Board 8, for a 30 HP reading on meter

APPENDIX 4

Basic Electrical (RLPC) Calibration Procedure

TRANSPORT CANADA

CLAYTON EMISSION DYNAMOMETER/RLPC

CALIBRATION CHECK LIST

DYNAMOMETER MODEL: ____________ DATE: ____________

SN : ____________

RLPC SN : ____________ TECHNICIAN: ____________

N.B. Allow 20 minutes for electronics to stabilite before proceeding with the calibration

A- LOAD WATER PRESSURE REGULATOR (glycool)

_ 1- Open the P.A.U. drain cock fully
_ 2- Air and water supply on (pump on)
_ 3- Lifts/roll brakes down or off
_ 4- Mode selector switch on control box to pendant
_ 5- While pressing the on button on the control pendant, observe the guage on the water regulator for a reading of 25 psi. Repeat several times to verify guage reading. Adjust if required and secure the lock nut.

Note: Guage reading will be higher with load valve closed.

_ 6- Close PAU drain cock.

B- P.A.U BLEED PORT AIR PRESSURE REGULATOR

____ 1- Air pressure supply on
____ 2- Lifts up or roll-brakes on
____ 3- Observe the guage on the air pressure regulator for a reading of 12 psi. Adjust if required and secure the lock nut.

C- WARM UP

____ 1- Dynamometer with warm up load operated minimum 20 min.
____ 2- Record P.A.U. temperature: ____ °F
____ 3- Negative lead of DVM to 1 TB common

D- REAR ROLL CALIBRATION

____ 1- Speed/Power switch to: Rear Roll

_ 2- Terminal 201 - T.G. output at 1800 R.P.M.: _ V.D.C.
_ 3- Positive lead of D.V.M. to terminal 324
_ 4- Adjust pot 3 board 8 to DVM reading of 0.000 ± .002 VDC (rolls stopped)
_ 5- Adjust pot 4 board 8 to DVM reading of 4.630 ± .002 VDC (Rear roll at 1800 R.P.M.) or synthetic value equal to T.G. output at 1800 R.P.M.
_ 6- Recheck pot 3 board 8 reading at 0.00 ± .002 VDC (Rolls stopped)

E- FRONT ROLL CALIBRATION

_ 1- Speed/power switch to: Front roll
_ 2- Terminal 206 - T.G. output at 1800 R.P.M.: _ VDC
_ 3- Positive lead of DVM to test point 5 board 7
_ 4- Adjust pot 6 board 7 to DVM reading of 0.000 ± .002 VDC (rolls stopped)
5- Adjust pot 7 board 7 to DVM reading of 4.630 ± .002 VDC (Front roll at 1800 R.P.M.) or synthetic value equal to T.G. output at 1800 R.P.M.
_ 6- Recheck pot 6 board 7 reading at 0.000 ± .002 VDC (Rolls stopped)

F- DIGITAL SPEED READOUT CALIBRATION

_ 1- Positive lead of DVM to test point 2 board 8
_ 2- Speed/power switch to: Front roll
_ 3- Switch 2 board 8 to: CAL (away from board)
_ 4- Switch 1 board 7 to: CAL (" " ")
_ 5- Adjust pot 5 board 8 to DVM reading of 5.000 ± .002 VDC
_ 6- Adjust span pot under logo on inst. box to 50.0 M.P.H. on digital speed meter

G- TORQUE CELL CALIBRATION

_ 1- Remove vehicle - lower lift - release brakes - remove calibration arbor
_ 2- Switches 1 & 2 board 8 & switch 1 board 7 to: Run (toward board)
_ 3- Positive lead of DVM to test point 4 board 8 reading (including + or - sign): _______________ V.D.C.
_ 4- Switch 2 board 8 & switch 1 board 7 to: CAL
_ 5- Adjust pot 5 board 8 to: 50 MPH reading on digital speed meter
_ 6- Positive lead of DVM to test point 1 board 8
_ 7- Remove load cell hysteresis (gently tap the load cell mounting channel)
_ 8- Adjust pot 1 board 8 to DVM reading of 0.060 ± .005 VDC
_ 9- Positive lead of DVM to test point 4 board 8
_ 10- Adjust pot 1 board 8 clockwise until DVM reading just equals reading at 3: _______________ V.D.C.

____ 11- Positive lead of DVM to test point 1 board 8 reading (include + or - sign): ________ V.D.C.
____ 12- Install arbor D33102 & tighten retaining screw to snug
____ 13- Gently install (3) D33112 weights - remove hysteresis
____ 14- Adjust pot 2 board 8 to DVM reading of 4.070 ± .002 V.D.C.
____ 15- Remove weights and arbor - remove hysteresis
____ 16- Compare DVM reading with reading in 11 within ± 0.002 VDC ________ VDC
____ 17- Adjust pot 1 board 8 to correct & repeat step 11 through 16

H- DIGITAL POWER READOUT CALIBRATION

____ 1- Adjust power meter reading to: 00.0 H.P. (remove front glass of the digital unit) (Both in case of 2 units) or (Remove instrument box cover)
____ 2- Replace glasses or cover
____ 3- Switches 1 & 2 board 8 and switch 1 board 7 to: CAL
____ 4- Adjust pot 5 board 8 to: 50 MPH (on digital speed meter)
____ 5- Positive lead of DVM to test point 1 board 8
6- Adjust pot 6 board 8 to DVM reading of 4.070 ± .002 VDC
7- Adjust power span pot for reading of: 40.7 H.P. (located under Clayton logo)

I- HORSE POWER SCALING VERIFICATION

____ 1- Switch 1 board 8 to: RUN (toward board)
____ 2- Switch 2 board 8 and 1 board 7 to: CAL
____ 3- Adjust pot 5 board 8 to: 50 MPH (on digital speed meter)
____ 4- Install as followed arbor & weighs and verify reading (vibrate after each wt.)

None: 00.0 ± 0.1 H.P. ________ H.P.

Arbor: 01.9 ± 0.1 H.P. ________ H.P.

Arbor + 35 pounds: 14.8 ± 0.1 H.P. ________ H.P.

Arbor + 70 pounds: 27.8 ± 0.1 H.P. ________ H.P.

Arbor + 105 pounds: 40.7 ± 0.1 H.P. ________ H.P.

____ 5- If not within tolerance steps G & H repeated to correct

J- HORSE POWER "CAL CHECK" CALIBRATION

____ 1- Warm up dynamometer for minimum 10 minutes
P.A.V.: ________ ° F
____ 2- Set mode selector switch to: Pendant
____ 3- Switch 2 board 8 & switch 1 board 7 to: CAL (Away from board)
____ 4- Switch 1 board 8 to: RUN (Toward board)
____ 5- Adjust pot 5 board 8 to: 50.0 MPH reading on digital speed meter

___ 6- Remove vehicle - lower lifts - release brakes
___ 7- Remove load cell hysteresis
___ 8- Press CAL button and record H.P. on digital meter
Reading: ________ H.P.

K- DEADBAND ADJUSTMENT

___ 1- Turn water supply to dynamometer off (or switch off the pump)
___ 2- Speed/power switch to: Front roll
___ 3- Set thumbwheel to: 30.0 H.P.
___ 4- Set mode selector to: thumbwheel
___ 5- Set vehicle factor to: 0.00
___ 6- Switches 1 & 2 board 8 & switch 1 board 7 to: CAL
___ 7- Adjust pot 5 board 8 to: 50MPH reading on digital speed meter
___ 8- Positive lead of DVM to terminal 312: ________ VDC
___ 9- Adjust pot 1 board 1 for -9.000 ± .002 VDC
___10- Adjust pot 6 board 8 to just start low rate unload light pulse
Reading: ________ H.P.
___11- Adjust pot 6 board 8 to just start low rate load light pulse
Reading: ________ H.P.
___12- Difference between 10 & 11: ________ H.P. This is the high deadband
___13- Adjust pot 3 board 2 and repeat 10 & 11 until high deadband equals 0.4 H.P.

L- THUMBWHEEL "LOW RANGE" ADJUSTMENT

___ 1- Set thumbwheel to: 03.0 H.P.
___ 2- Set mode selector to: thumbwheel
___ 3- Set vehicle factor to: 0.00
___ 4- Switches 1 & 2 board 8 and switch 1 board 7 to: CAL
___ 5- Adjust pot 5 board 8 to: 50.0 MPH reading on digital speed meter
___ 6- Adjust pot 6 board 8 to: 3.0 H.P. reading on digital power meter
___ 7- Adjust pot 1 board 7 until low & high rate load & unload lights go out
___ 8- Adjust pot 6 board 8 counter clockwise to just start low rate unload light pulse
Reading: ________ H.P.
___ 9- Adjust pot 6 board 8 clockwise to just start low rate load light pulse
Reading: ________ H.P.
___10- Difference between 8 & 9 is: ________ H.P. This is the low deadband
___11- Adjust pot 1 board 7 to center deadband around 3.0 H.P. - (3.2/2.8)

M- THUMBWHEEL "SPAN" ADJUSTMENT

___ 1- Set thumbwheel to: 39.0 H.P.
___ 2- Set mode selector to: thumbwheel
___ 3- Set vehicle factor to: 0.00
___ 4- Switches 1 & 2 board 8 & switch 1 board 7 to: CAL

___ 5- Adjust pot 5 board 8 to: 50MPH on digital speed meter
___ 6- Adjust pot 6 board 8 to: 39.0 H.P. on digital power meter
___ 7- Adjust pot 8 board 7 until low & high rate load/unload lights go out
___ 8- Adjust pot 6 board 8 counter clockwise to just start low rate unload light pulse Reading: ______ H.P.
___ 9- Adjust pot 6 board 8 clockwise to just start low rate load light pulse Reading: ______ H.P.
10- Difference between 8 & 9 is: ______ H.P. This is the thumbwheel span
___11- Adjust pot 8 board 7 to EXACTLY center around 39.0 H.P. - (39.2/38.8) (Repeat L & M as necessary for correction)

N- HIGH RATE DEADBAND ADJUSTMENT

___ 1- Set thumbwheel to: 39.0 H.P.
___ 2- Set mode selector to: THUMBWHEEL
___ 3- Set vehicle factor to: 0.00
___ 4- Switches 1 & 2 board 8 & switch 1 board 7 to: CAL
___ 5- Adjust pot 5 board 8 to: 50 MPH on digital speed meter
___ 6- Adjust pot 6 board 8 to: 40.5 H.P. on digital power meter
___ 7- Adjust pot 1 board 3 to just start high rate unload light
___ 8- Adjust pot 6 board 8 to: 37.5 H.P. on digital power meter
___ 9- Adjust pot 1 board 2 to just start high rate load light

Note: Any of these adjustments affects items K & L - recheck K & L

___10- Re adjust pot 6 board 8 to DVM reading of 4.070 ± .002 VDC as per H
Reading: ______ VDC

O- DRIVER CUT OFF ADJUSTMENT

___ 1- Set thumbwheel to: 0.00 H.P.
___ 2- Switches 1 & 2 board 8 & switch 1 board 7 to: RUN
___ 3- Positive lead of DVM to test point 1 board 8
___ 4- Adjust pot 1 board 8 to DVM reading of + 0.060 ± .005 VDC
___ 5- Adjust pot 2 board 3 clockwise to just stop both low & high rate unload lights
___ 6- Remove hysteresis
___ 7- Adjust pot 1 board 8 to same reading as recorded in G 11
Reading (include + or - sign): ______ VDC

P- FINAL SYSTEM PREPARATION

___ 1- Switches 1 & 2 board 8 & switch 1 board 7 to: RUN
___ 2- Remove DVM leads
___ 3- Reinstall cover on R.L.P.C.
___ 4- Return logo on instrument box (es) to horizontal

5- Turn water supply ON (glycol)

THE SYSTEM IS NOW CALIBRATED AND READY FOR OPERATION.

TECHNICIAN: ____________________

DATE: ____________________

G.P.

APPENDIX 5

Procedure for Determining Dynamometer Frictional Power Losses

PROCEDURE FOR DETERMINING DYNAMOMETER FRICTIONAL POWER LOSSES

This specified procedure is used to determine the residual frictional horsepower losses caused by drive roll bearings, the engagement of flywheel bearings, and rotating component windage. The actual horsepower (HP_d) at the vehicle tire/roll interface can be calculated from the dissipation of kinetic energy as the dynamometer rolls and flywheels coast down through a known speed range at a measured time interval. The HP_d includes both frictional losses HP_f and power absorbed by the water brake, HP_i, which is indicated by the dynamometer horsepower display.

Thus:

$$HP_d = HP_f + HP_i$$

This procedure assumes that the torque, speed, and electronic circuits have been calibrated as previously described. The following is the procedure to be used.

1. Ensure that the cold room is at a nominal temperature of + 25°C (77°F);

2. Turn on dyno glycol pump;

3. Turn on - road load power control
   - coastdown timer

   and allow 30 minutes for electrical warmup and stabilization.

4. Check dyno air pressure;

5. Apply dyno lift brakes

6. Install and align the slave vehicle (rear wheel drive Ford Pinto) on the dyno rolls;

7. Set drive tire pressure to 45 psi;

8. Install the vehicle lifting device. Connect the air supply and electrical power. Verify proper operation (fast-up, slow-down);

9. Install - front wheel shocks;
   - exhaust ducting;
   - radiator and tire cooling fans;
   - tie-down straps
   - roll guards;

10. Open hood of slave vehicle;

11. Set dynamometer controls:

    Inertia Weight Selected - 2500#
    Thumbwheel Setting - 7.0 HP
    Selector Switch - Thumbwheel
    Vehicle Factor Pot - 0.0
    Press Index Light
    Speed Power Switch - Front Roll

Since all tests were run at an inertia weight setting of 2500#, this is the only setting considered in the frictional horsepower determination.

12. Release dyno lift brakes;

13. Switch on - building exhaust fan;
    - engine and roll fans;

14. Start slave vehicle;

15. Check that required inertia wheels are turning;

16. Run slave vehicle for 30 minutes at 60 mph to warm up dynamometer;

17. Accelerate to 50 mph front roll speed and verify that the selected thumbwheel value is within ±0.2 HP of the HP display. Record this data;

18. Accelerate to 62 mph and reset the coast down timer counter;

19. Activate the vehicle lift and maintain vehicle speed until the tires have cleared the roll. Release the accelerator;

20. Watch the timer and verify that the counter starts and stops at 88 and 72 km p.h. (55 and 45 mph);

21. Record coastdown time;

22. Bring the vehicle speedometer reading to within ±5 mph of the front roll speed and release the lifting device to allow the vehicle to contact rolls again;

23. Repeat steps 17 to 22 two more times;

24. If the three coastdown times recorded are not within 0.5 seconds, repeat steps 17 to 22 three more times;

25. Calculate the frictional horsepower using the following relationships:

$$HP_d = \frac{(\text{Inertia Weight} - 155\ \text{lb}) \times 0.060734}{\text{Average Coastdown Time (Sec.)}}\ HP$$

$$HP_f = HP_d - HP_i \quad \text{(Thumbwheel Setting)}$$

26. Repeat steps 17 to 25 for a thumbwheel setting of 5.0 HP and 6.0 HP;

27. Average the HP_f calculated in step 25 for 5.0, 6.0, and 7.0 HP_i. This average frictional horsepower should then be used for all testing at 2500# inertia weight.

28. Record all data on attached sheet.

29. Stop slave vehicle;

30. Turn off building exhaust fan and engine and roll fans;

31. Remove:
    - vehicle lift device;
    - shocks;
    - exhaust duct
    - cooling fans
    - tie-down strap
    - roll guards.

DYNAMOMETER COASTDOWN DATA SHEET

Date ____________
Time ____________
Cell Temp. ____________
% RH ____________
Barometric Pr. ____________

Time Warmup started ____________
completed ____________

Time Coastdowns started ____________
completed ____________

Inertia Weight Setting 2500#

Coastdown Times

RL HP Setting (HP)	5.0	6.0	7.0
Coastdown #1			
#2			
#3			
#4			
#5			
#6			
Average Time (sec.)			
HP_d			
HP_f			

Average HP_f @ 2500# ____________

Comments: ____________

Calculations:

$$HP_d = \frac{(\text{Inertia Wt} - 155 \text{ lb}) \times .060734}{\text{Average Time}}$$

$$HP_f = HP_d - \text{RLHP Setting}$$

HP_d = ____________ HP_f = ____________

APPENDIX 6

Procedure for Plotting Torque Versus Speed and HP Versus Speed Curves

PROCEDURE FOR PLOTTING TORQUE; HORSEPOWER VS SPEED CURVES

This appendix describes the procedure for plotting the torque and horsepower versus speed curves through the electrical road load power control unit. By comparing these curves with the theoretical plots, one can tell immediately if there is a problem with calibration of the RLPC unit. The theoretical plots (see Figure A6-1) are based on an indicated power setting of 11.0 HP at 80 km/hr (50 mph) and are a function of the $T \propto V^2$ and $HP \propto V^3$ relationships. Typical test procedure is as follows:

1. Allow 30 minutes for electronic instrumentionation to stabilize.

2. Warmup dynamometer for 20 minutes.

3. Panel Setup:

Thumbwheel	11.0 HP
All switches	Run
Power Speed	Front
Mode	Thumbwheel
Vehicle Factor	0.0

4. Insert 11" x 14" sheet of graph paper containing theoretical curves in x-y plotter, zero the plotter and set the following spans:

   a) Torque - Speed Plot
   Torque - Y Axis; 2 volts = 54 lb_f - ft
   Speed - X Axis; 5 volts = 50 mph

   b) Horsepower - Speed Plot

   Horsepower - Y Axis; 0.5 volts = 20 HP
   Speed - X Axis; 5 volts = 50 mph

5. Plug leads from RLPC unit into the input of the X-Y recorder according to the following formatL

   a) Torque - Speed Plot

      Torque - Y + Input; Terminal 316
      Y - Input; RLPC "common"

      Speed - X + Input; Terminal 325
      X - Input; RLPC "common"

   b) Horsepower - Speed Plot

      Horsepower - Y + Input; Terminal 301
      Y - Input; RLPC "common"

      Speed - X + Input; Terminal 325
      X - Input; RLPC "common"

(Note: Be careful not to short out the RLPC unit when connecting these leads.)

6. Lower the pen on the X-Y plotter and drive up to 60 mph on the dynamometer very slowly, change pen colors at 60 mph and decelerate slowly to a stop. (This procedure will have to be followed twice; once for torque vs speed curve, and once for the horsepower speed curve).

A comparison of the actual curves and those suggested by theory reveals a great deal about the state of the electrical RLPC unit. Some "hunting" on the torque-speed plot during acceleration is normal up to speeds of about 20 mph. Any oscillation in the curve beyond this speed indicates that the dead band adjustment portion of the RLPC calibration needs to be reset. If the exponent to the curve does not match that suggested by the manufacturer, then Section E of the factory calibration procedure (Appendix 3) needs to be repeated. If the exponent is correct but the curves are offset from the correct plots (and the zeros and spans were set correctly at the beginning), then a dead weight calibration should be done on the load cell (Section G-1 of basic calib - Appendix 4)

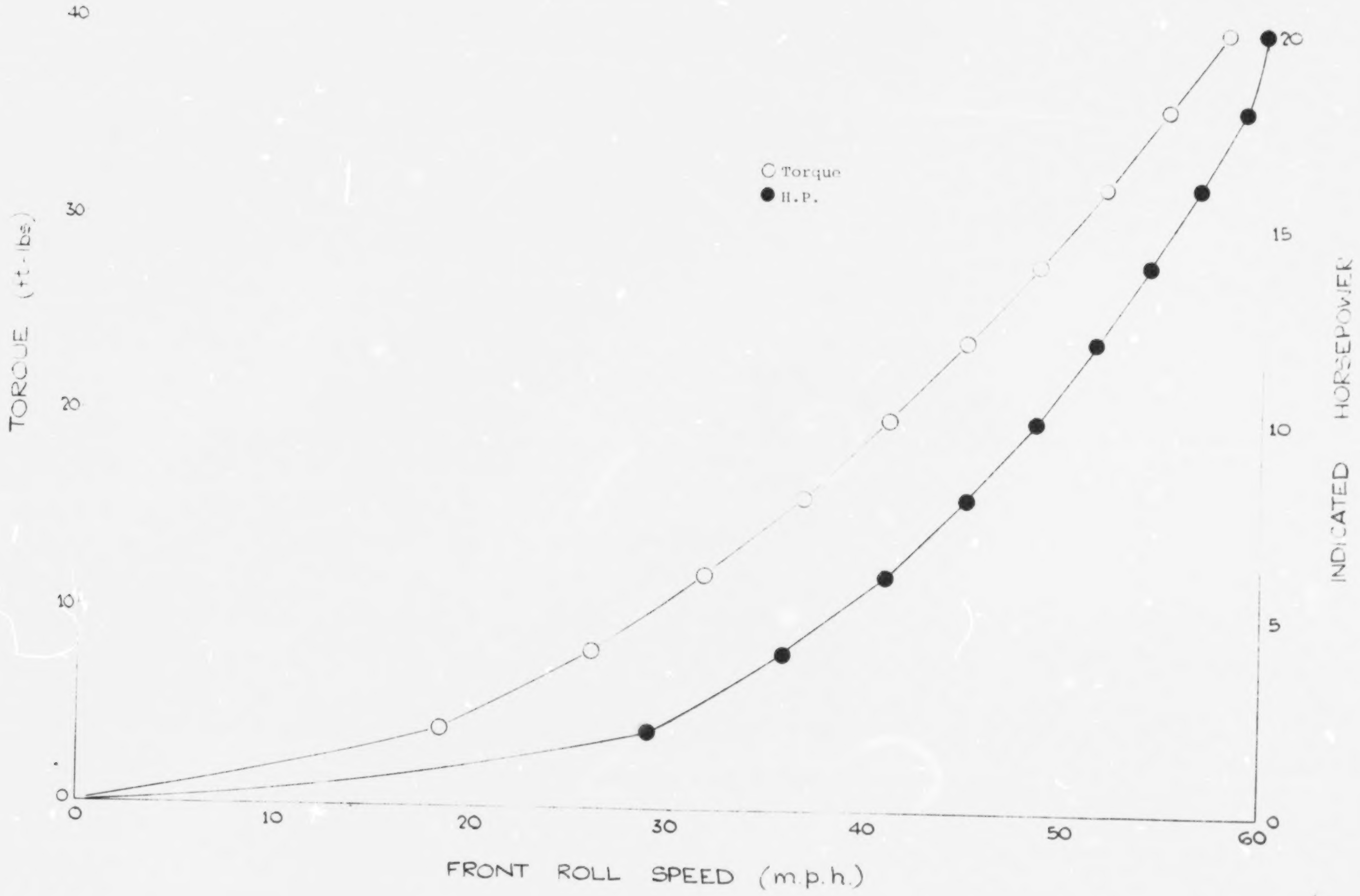


Figure A6-1 - Theoretical Torque/Horsepower Versus Front Roll Speed Characteristics For Clayton CTE 50 Dynamometer

APPENDIX 7

Transport Canada City Driving Cycle

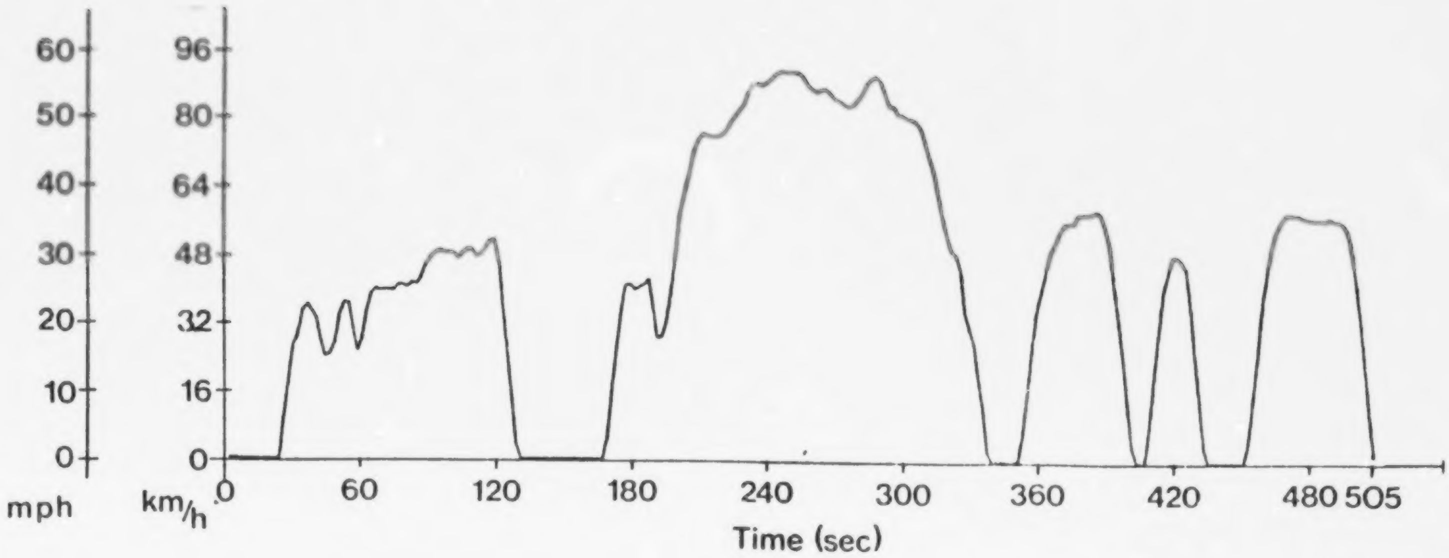


Fig. A7-1: City Driving Cycle - Cold Transient

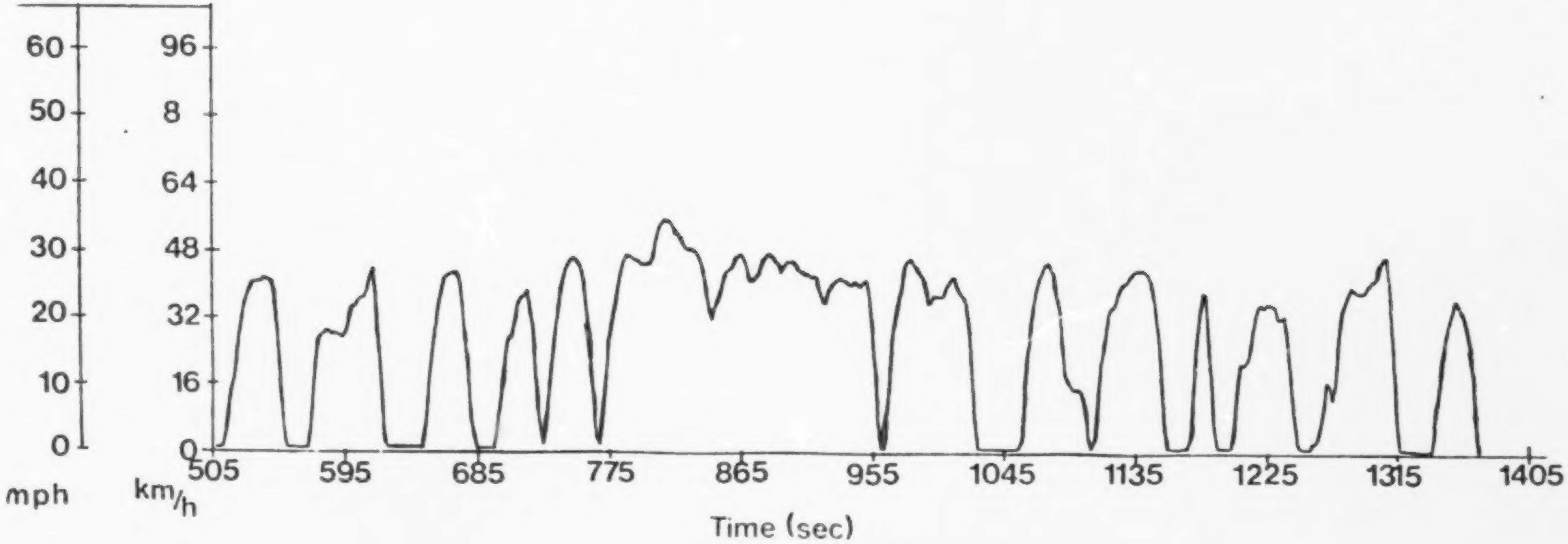


Fig. A7-2: City Driving Cycle - Cold Stabilized

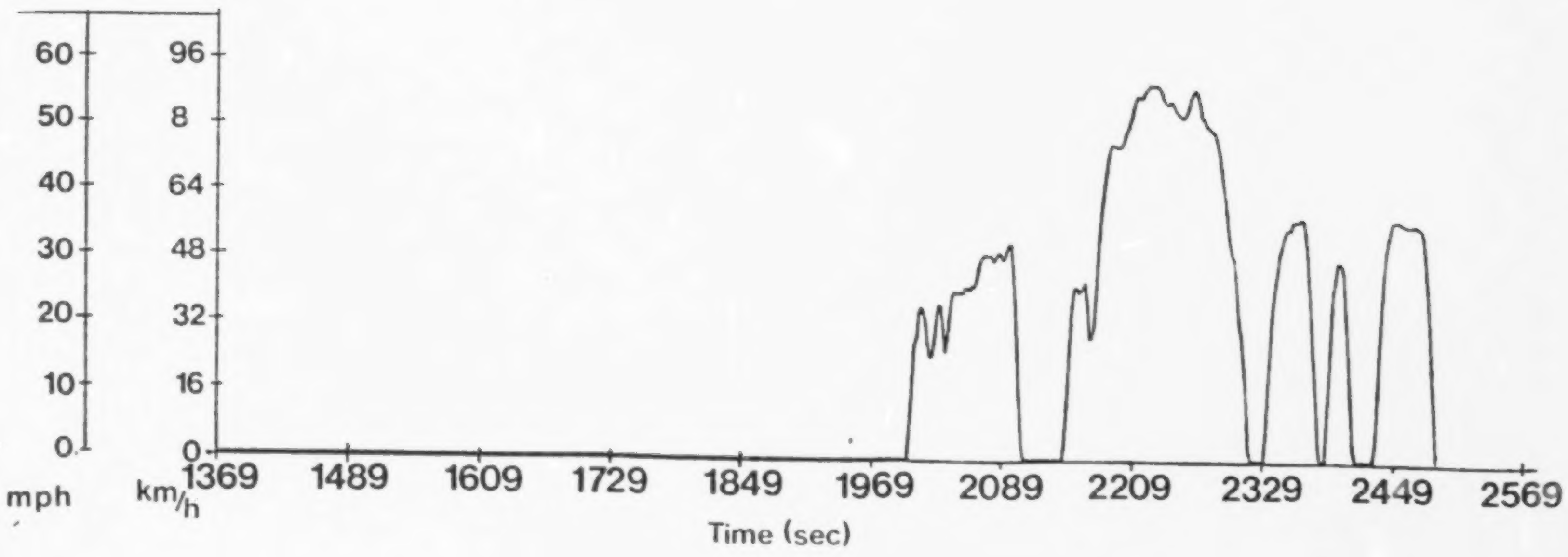


Fig. A7-3: City Driving Cycle - City Cycle Hot Soak & Hot Transient

APPENDIX 8

Transport Canada Highway Driving Cycle

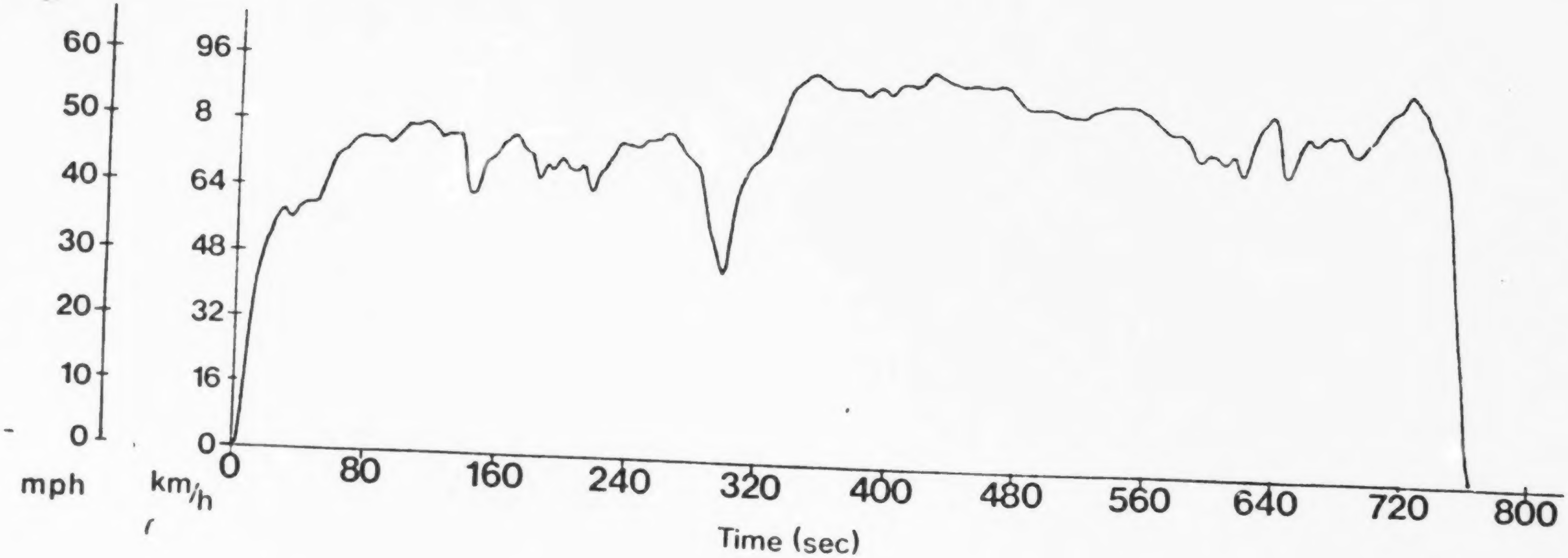


Fig. A8-1: Highway Driving Cycle

APPENDIX 9

Cold Weather Test Program
Formal Lab Procedure

COLD WEATHER PROGRAM
DYNO TEST SUMMARY

GENERAL

Date
Vehicle No.
Test No.
Driver
Instr. Op.
Battery S.G.
(min. 1250)

SOAK

Time (Start)
Time (End)
Soak Time
Av. Soak Temp (°C)
Δ Evap. Can. Wt (gm)
  Start Soak
  End Soak

TEST PARAMETERS

Inertia Weight (lb.)
HP - indicated
  - determined

AVERAGE TEST CONDITIONS

Temperature (°C)
Relative Humidity (%)
Bar. Pressure ("Hg)
Fuel Temperature (°C)
Hot Curb Idle
Basic Timing (Hot)

COLD START

Time to First Fire (sec.)
Crank Time to Start (sec.)
Cranking rpm
No. Die-Outs
Fast Idle rpm
Choke Full Off Time (sec.)

ODOMETER

Start of City (km)
End of Hwy (km)
Test Distance

POST TEST

N/V
Quick Coast (sec.)

	BAG 1*	BAG 1	BAG 2		BAG 3			HWY
			End	Δ	Start	End	Δ **	
Fuel Cons. (gm)								
Dyno Revs								

	CITY*	CITY	HWY	COMB*	COMB
WEIGHTED FUEL CONS. (l/100th km)					

* Includes addition of Δ Evap. Can. Wt in Bag 1.

** (End Bag 3) -)End Bag 2).

DYNAMOMETER TEST PROCEDURE

References:
a) Motor Vehicle Safety Test Methods, Chapter IV, Section 1101, Vehicle Emissions

b) Fuel Consumption Program Guidelines

c) Current EPA Circulars

d) Emission Dynamometer Systems Manual

Annex A - Example of Dynamometer Setting

Annex B - Mechanical Calibration Chart

Annex C - Flywheel Engage Chart

Annex D - Fuel Consumption Calculations - Gravimetric Method

Annex E - Urban & Highway Cycle - Calculation & Tolerance

Annex F - Vehicle Operation - Choke
- Stalling
- Restarting

LABORATORY TEST PROCEDURE

N.B. 1) The dynamometer must have been operated within the past:

- two hours at ambient temperatures of 20°C to 30°C;
- one hour at ambient temperature $< 20°C$;

otherwise a dyno warm-up would be required.

PREPARATION

VEHICLE

- Check dyno air pressure - 90 psi ☐
- Apply dyno lift brakes (Roll brakes light - ON) ☐
- Put test vehicle on dyno. DO NOT START ENGINE. ☐
- Release dyno lift brakes ☐
- Align test vehicle by MANUALLY rotating rolls several turns until vehicle centred ☐
- Apply dyno lift brakes ☐
- Install
  - chocks ☐
  - exhaust ☐
  - fans ☐
  - safety straps ☐
  - roll guards ☐
- Tire pressure 45 psi ☐
- Vehicle electrical accessories OFF ☐
- Record odometer reading ________________ km
- Measure vehicle battery S.G. (Change battery if necessary) ☐

FUEL SYSTEM CONNECTION AND PURGING

- Turn off electric fuel pump ☐
- Open electric fuel pump bypass valve ☐
- Close carburetor supply valve ☐
- Close vehicle mechanical fuel pump supply valve ☐
- Open purge valve in return circuit ☐

- Connect feed and return lines at fuel cannister ☐
- Open fuel cannister vent valve ☐
- Connect feed and return lines at test vehicle ☐
- Close electric fuel pump bypass valve ☐
- Turn on electric fuel pump and purge until all air evacuated ☐
- Open carburetor supply valve SLOWLY ☐
- Close purge valve in return circuit ☐
- Disconnect return line at fuel cannister ☐

TRANSDUCER HOOK-UPS TO TEST VEHICLE

CAUTION -- KEEP ALL CABLES AWAY FROM FAN

- Weigh charcoal evap. cannister and reinstall ☐

  ______________ gm
- Connect vehicle battery (Master Power Switch) ☐
- Install magnetic timing probe ☐
- Install inductance clip on cyl # 1 high tension lead ☐
- Install vacuum transducer ☐
- Connect battery voltage leads ☐
- Connect choke position transducer leads ☐
  CHECK POSITION ON WATANABE
- Connect thermocouple leads ☐
- Place exhaust analyser probe in tailpipe ☐
- Place driver's remote control box in test vehicle ☐
- Close test vehicle hood ☐

ROAD LOAD POWER CONTROL

- Dyno glycol circulation pump ON ☐
- Roll brakes light ON ☐

- 2500# inertia weight selected ☐
- Dyno frictional power for wheels 1 + 4 + 5 + rolls ☐ = ________ H.P.
- Date of mechanical cal chart used ____________
- Indicated power = 7.9 HP - frictional HP
  = ____________ HP
- Set thumbwheel at ____________ HP ☐
- Selector switch in Thumbwheel Position ☐
- Vehicle factor potentiometer set at 0.00 ☐
- Press index light - light flashing ☐
- Speed/Power switch - REAR ROLL ☐
- Release dyno lift brakes (Roll brakes light OFF) ☐
- Inertia wheels 1, 4 and 5 turning (Turn rolls manually) ☐
- Check driver's aid - paper ☐
  - ink ☐
  - pen ☐
  - electrical zero ☐
- Position drivers aid chart at 0 sec. ☐

INSTRUMENTATION

- Level weigh scale ☐
- Turn on CO sample pump ☐
- Check Watanabe paper ☐
- Check Watanabe traces (all channels operating) ☐
- Check data logger paper ☐
- Check data logger (all channels operating) ☐

- Load cassette into Memodyne with BROWN SIDE UP. (Ensure adequate tape available on cassette. Tape runs right to left) ☐

TEST CYCLES

N.B. 1) Follow manufacturer's starting procedures.

Cold Start At 25°C and 0°C

a) Depress accelerator pedal all the way to floor and release.

b) Turn key to start engine.

c) Let engine idle for 5 sec., then lightly depress and release accelerator pedal.

Cold Start at -20°C

Depress the accelerator pedal all the way to the floor, release to 1/3 throttle open position, and hold accelerator pedal in this position while starting engine.

Hot Start (After 10 min. Soak At All Temps.)

Depress accelerator pedal to 1/3 open position and hold while starting engine.

2) Be familiar with Annex F - Stalling and Restarting.

- Start exhaust fan ☐
- Start engine and roll fans ☐
- Put on hearing protection ☐

URBAN CYCLE

- Zero weigh scale ☐
- Zero roll rev counter ☐
- Start data logger ☐
- Record cell barometric pressure ____________________ in. Hg

BAG 1

- Start Watanabe at 600 mm/min ☐
- Start test vehicle ☐
- Reduce Watanabe chart speed to 75 mm/min after test vehicle starts ☐
- Indicate change of Watanabe chart speed on chart paper ☐
- SIMULTANEOUSLY
    - start driver's aid ☐
    - initiate data logger reading ☐
    - indicate time 0 on back of data logger printout ☐

AT 505 sec.

- SIMULTANEOUSLY
    - sound test vehicle horn ☐
    - initiate data logger reading ☐
    - MANUALLY record
        - Fuel used __________ gm
        - Dyno roll revs ________
    - Indicate 505 sec. on back of data logger printout ☐

BAG 2

AT 1369 sec.

- SIMULTANEOUSLY
    - turn off vehicle ignition ☐
    - sound test vehicle horn ☐
    - initiate data logger reading ☐
    - MANUALLY record
        - Fuel used ____________ gm
        - Dyno roll revs __________
- Indicate 1369 sec. on back of data logger printout ☐

HOT SOAK

- Turn off electric fuel pump ☐
- Open electric fuel pump bypass ☐
- Stop cooling fans ☐
- Stop exhaust fan ☐
- Position driver's aid at 0 sec. ☐
- At 9.5 minutes close electric fuel pump bypass ☐
- Just before 10 min.
    - start exhaust fan ☐
    - start cooling fans ☐
- Wait 10 min. before BAG 3

BAG 3

DO NOT ZERO SCALE OR ROLL REV COUNTER

- SIMULTANEOUSLY
    - sound test vehicle horn ☐
    - start electric fuel pump ☐
    - start test vehicle engine ☐
- SIMULTANEOUSLY
    - start driver's aid ☐
    - initiate data logger reading ☐
    - indicate start of BAG 3 on back of data logger printout ☐

AT 505 sec.

- SIMULTANEOUSLY
    - sound test vehicle horn ☐
    - initiate data logger reading ☐
    - MANUALLY RECORD - Fuel used ____________ gm

      - Dyno roll revs ____________
- Leave test vehicle running and shift into Neutral ☐
- Leave driver's aid running ☐
- Record cell barometric pressure ____________ in. Hg.

- When idle stable
  - Manually record
    - hot curb idle __________ rpm
    - basic timing __________ °
  - Initiate data logger reading and note
    - manifold vacuum __________ in. Hg.
    - carb in temp. __________ °C
    - fuel temp. __________ °C
    - cell temp. __________ °C
- Shift into Drive and prepare for highway test ☐

CITY FUEL CONSUMPTION CALCULATION (CORRECTED FOR Δ EVAP. CANNISTER)

Fuel Consumed (gm)

= [0.43 (BAG 1 + Δ Evap Can) + (BAG 2) + 0.57 (BAG 3)]

= 0.43 (+   ) + (   ) + 0.57 (   )

= __________ gm

Roll Revs = 0.43 (BAG 1) + (BAG 2) + 0.57 (BAG 3)

= 0.43 (   ) + (   ) + 0.57 (   )

= __________ revs

Fuel Consumption (l/100 km)

$$= \frac{\text{Fuel Consumed (gm)} \times 144.686}{\text{Roll Revs} \times \text{Fuel Specific Gravity}}$$

$$= \frac{\qquad \times 144.686}{\qquad \times 0.7003}$$

= __________ l/100 km

Report result on first page ☐

CITY FUEL CONSUMPTION CALCULATION (NOT CORRECTED FOR Δ EVAP. CAN.)

Fuel Consumed (gm)

= [0.43 (BAG 1) + (BAG 2) + 0.57 (BAG 3)]

= 0.43 (   ) + (   ) + 0.57 (   )

= ______________ gm

Roll Revs = 0.43 (BAG 1) + (BAG 2) + 0.57 (BAG 3)

= 0.43 (   ) + (   ) + 0.57 (   )

= ________________ revs.

Fuel Consumption (1/100 km)

$$= \frac{\text{Fuel Consumed (gm)} \times 144.686}{\text{Roll Revs} \times \text{Fuel Specific Gravity}}$$

$$= \frac{\qquad\qquad \times 144.686}{\qquad\qquad \times 0.7003}$$

= ______________ 1/100 km.

Report result on first page ☐

COMMENTS

RECORD ANY TEST ABNORMALITIES OR PERTINENT COMMENTS

HIGHWAY CYCLE

N.B. Highway Preconditioning to be performed if test vehicle has been stopped for longer than 15 minutes.

- DO NOT ZERO SCALE OR ROLL REV COUNTER ☐
- Check fuel container for adequate fuel ☐
- Check driver's aid - paper ☐
  - ink ☐
  - pen ☐
  - zero ☐
- Check Watanabe paper ☐
- Check data logger paper ☐
- Check Memodyne tape ☐
- Start Highway Test Cycle ☐
- SIMULTANEOUSLY at chart instruction "Start Of Sample Period"
  - sound test vehicle horn ☐
  - initiate data logger reading ☐
  - indicate start of Highway Test Cyele on back of data logger printout ☐

AT END OF HWFET SAMPLE PERIOD (915 sec.)

- SIMULTANEOUSLY
  - sound test vehicle horn ☐
  - initiate data logger reading ☐
  - MANUALLY RECORD - Fuel used ______________ gm
    - Dyno Roll Revs ______________
- Record odometer reading ____________________ km
- Leave test vehicle running ☐
- Open hood of test vehicle ☐
- Deinstrument test vehicle ☐
- Turn off electric fuel pump ☐

- Open electric fuel pump bypass ☐
- Disconnect fuel cannister feed and return lines at test vehicle ☐
- Open mechanical fuel pump supply valve ☐
- Record cell barometric pressure ______________ in. Hg.

HIGHWAY FUEL CONSUMPTION CALCULATION (SEE ANNEX D)

Highway Fuel Consumption (1/100 km)

$$= \frac{\text{Fuel Consumed (gm)} \times 144.686}{\text{Roll Revs} \times \text{Fuel Specific Gravity}}$$

$$= \frac{\_\_\_\_\_\_ \times 144.686}{\_\_\_\_\_\_ \times 0.7003}$$

= ____________ 1/100 km

Report result on first page ☐

COMMENTS

RECORD ANY TEST ABNORMALITIES OR PERTINENT COMMENTS

PRECONDITIONING

N.B. Complete After Highway Test Cycle ☐

- Open hood of test vehicle (if not open already) ☐
- Run test vehicle at 50 mph for 20 min. (REDUCE SPEED IF ENGINE OVERHEATING) ☐
- At 15 min. remove and weigh evap. cannister ____________ gm
- Reinstall evap. cannister before end of preconditioning run ☐
- Perform three quick coastdowns ____________ sec.
  ____________ sec.
  ____________ sec.
- Stop test vehicle engine ☐
- Stop cooling fans ☐
- Stop exhaust fan ☐
- Disconnect test vehicle battery (using master disconnect switch) ☐
- Close hood of test vehicle ☐
- Apply dyno lift brakes (Roll brakes light ON) ☐
- Remove
  - chocks ☐
  - exhaust ☐
  - fans ☐
  - safety straps ☐
  - roll guards ☐
- Remove test vehicle from dyno (DO NOT START TEST VEHICLE ENGINE) ☐
- Refill test vehicle fuel tank if necessary ☐
- Refill fuel cannister if necessary ☐

COMMENTS

RECORD ANY ABNORMAL CONDITIONS OR PERTINENT COMMENTS.

APPENDIX 10

Test Quality Control Data

TEST QUALITY CONTROL SHEET

N.B. The following criteria should be considered when assessing the validity and subsequent acceptance or rejection of a test run. These criteria should be used as a guide with judgment exercised in the final decision.

Item	Test Value	Suggested Tolerance	In Tol.	Out of Tol.
Driver's aid trace*		See para 8.6.2 of Test Method		
At end of BAG 3				
Hot Curb Idle		850 - 1000 rpm		
Basic Timing		13° - 17°		
Manifold Vac.		18" Hg nominal		
Carb in Temp		23°C - 43°C		
Av. Cell Temp		± 5°C of set temp		
Av. Fuel Temp		± 5°C of cell set temp		
Bag 1 Roll Revs		8362 revs ± 2.5%		
Bag 2 Roll Revs		9020 revs ± 3%		
Bag 3 Roll Revs		8400 revs ± 2%		
Highway Roll Revs		23935 revs ± 3%		
Av. Quick Coastdown		11.5 sec ± 10%		
Total Test Time		54 min ± 7%		
Hot Soak Time		10 min ± 2%		
Odometer Difference		34 km ± 6%		

* Note times at which out of tolerance ____________________

____

Run: Valid ☐, Void ☐.

APPENDIX 11

Track Coastdown Procedure

COASTDOWN TESTING

A
REPORT
ON THE DEVELOPMENT OF A
COASTDOWN TEST PROCEDURE

BY
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ABSTRACT

The developed coastdown procedure involved basically track testing, computer analysis and dynamometer testing.

Development began after adequate information, including a previously written computer program had been obtained. The program, received from the Environmental Protection Agency (EPA) of the USA, has now been adopted to the Transport Canada computing facility. Sample results are presented and are in close correlation to manufacturers estimates.

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COASTDOWN TESTING

A REPORT ON
COASTDOWN TESTING PROCEDURE

1. Introduction

The Energy and Emissions Section of Transport Canada publishes manufacturer's fuel consumption data in their "Fuel Consumption Guide". To insure uniformity, all manufacturers have agreed to use the Transport Canada dynamometer fuel consumption test method. This method involves driving representative vehicles on a chassis dynamometer over two separate standard driving cycles; one for city and the other for highway style driving.

To properly reproduce vehicle load characteristics on the dynamometer, two parameters must be chosen. These are the vehicle weight and a number representative of the aerodynamic and rolling resistance losses. The loaded vehicle weight is based on the vehicle curb weight plus 300 lb. (136 kg) and is simulated by using a combination of flywheels. The loaded vehicle weight has a representative dynamometer inertia weight setting called the "Equivalent Test Weight". These Equivalent Test Weights can be determined using Appendix A3.

The friction losses are simulated by using a water brake Power Absorption Unit (PAU). The PAU setting represents the power absorbed at a steady 50 mph vehicle speed and is called the Road Load Horse Power (RLHP). There are two basic methods for determining the RLHP of each vehicle. The first is a formula method based largely on frontal area and shape, but also including protuberance area, tire type and air conditioning power. The second method is through coastdown testing, which is explained in, and is the purpose of this report.

The manufacturer is given the option of performing coastdown testing to determine the actual RLHP. This has advantages for vehicles which are expected to perform better than the typical vehicles addressed in the first method. Briefly, the method involves allowing the vehicle to coastdown on a test track to obtain speed V.S. time data which is massaged through the computer program to give us an expected coastdown time between 55 and 45 miles per hour. The vehicles is then mounted on a dynamometer at the appropriate inertia weight setting and the PAU setting is adjusted until similar coastdown times are obtained.

This report deals with the development of the coastdown testing procedure and the presentation of typical test results.

2. Model Analysis

The purpose of the analysis is to model the vehicle coastdown characteristics so that they may be reproduced on the dynamometer. This method was first used by White and Korst and a more rigorous and complete treatment can be found in references (1), (2), and (3).

To save time and effort the computer program mechanically goes through the steps to determine a target coastdown time as follows. To begin, a form is assumed for the deceleration forces on the coasting vehicle. This is the sum of aerodynamic and rolling resistance effects. The rolling resistance is assumed constant and the aerodynamic drag varies as the square of the speed. Using the known mass, an expression for the resultant deceleration can be found. Analytical integration of this expression gives the velocity as a function of time in terms of two parameters representative of air resistance and rolling resistance losses. These parameters can be determined for each vehicle by fitting the experimental data obtained from track coastdown tests to the velocity equation.

The above analysis is performed for each run. Any run whose root-mean-square error when compared to its analytical counterpart exceeds ±0.25 mph must be discarded along with its paired run in the opposite direction. The coefficients for the remaining runs are then averaged. If the standard deviation of the rolling resistance term exceeds ±2.25 lb. or that of the aerodynamic term exceeds ±0.001 lb. per $(\text{mph})^2$ then the run and it's pair furthest from the mean must be discarded. This step is then repeated until the above requirements are met. If the number of remaining pairs falls below three then all pairs must be discarded and the test repeated.

The remaining runs are next individually corrected for wind. Following this the average coefficients are corrected to standard ambient conditions of temperature (68°F) and pressure (29.0 in. Hg.). The dynamometer target coast time is calculated after a final mass correction. For convenience the coast time for a series of inertia weight settings near the equivalent test weight is calculated.

To determine the actual road load horsepower of the vehicle in question, the inertia wheels are set to simulate the equivalent test weight. The thumbwheel setting is then adjusted, varying the PAU drag coefficients until the target coastdown time is matched on the dynamometer. The thumbwheel display (H.P.) is then added to the frictional Horsepower of the inertia wheels to determine the total Road Load Horsepower.

All coastdowns are done with the vehicle shifted into neutral and on the rolls with the timer and roll selector switch set on front roll.

3. Computer Analysis

The United States Environmental Protection Agency (EPA) have developed a computer program to perform the above analysis. This was made available to Transport Canada and has been adapted to run on the in-house computer facility (IBM-370). A sample run was sent to EPA for verification. The results were in total agreement.

To perform the analysis, several steps are required. First the vehicle identification and test information data, along with the fifth wheel voltage readings, must be punched onto computer cards in the required format. This format is detailed in the Appendix C1A. An example coding form is filled with sample data Appendix C1C, preceeded by an explanation of format codes in Appendix C1B.

Using a filled in coding form, one may either have the cards punched or punch them himself. Examples of correctly punched decks are data decks "COAST.DATA 400 - COAST.DATA. 900. ALL COLORED CARDS in these decks are essential for proper execution.

Once the deck has been processed through computer services on the 15th floor a new file with the converted voltage to speed data will be found in the list of DATA SET NAMES on Wylbur files accredited to account No. E91.E7025C.

In order to convert voltage data to speed data,the data deck created is run through a conversion program (COAST.DATA. CONV)*, to convert the fifth wheel voltages to speed readings using a calibration factor "CALIB". The determination of the factor is explained in section 4.2 - instrumentation. This calibration factor must be changed in the conversion program before the data deck is processed if the 5th wheel used is different from that used in the previous test. This change and other program amendments may be accomplished using the condensed Wylbur users guide in Appendix C1D. In order for the converted data to be saved as a Wylbur file on your account two (2) cards must be amended on each run.

1. Card #1 is the first white card or the 7th card in the deck. The first three column numbers are changed so that data file identification is made more easily. Amendment of this card is not essential for conversion program execution.

2. Card #2 is the 4th last card in the deck on which the converted data file name is present. e.g.: "COAST.DATA 400". The three numbers e.g.: "400" must be amended on each execution as new files cannot be stored under names of files already on disk. These three numbers should correspond to the three (3) number changes made to card #1.

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on Wylbur files

The conversion program writes the header data and the converted speed data onto a computer file which is suitable for input to the coastdown program, (COAST.EXEC)*.

By running a set of Job Control Statements on Wylbur file (COAST.EXEC) the computer program (COAST.SOURCE) is compiled and the raw data created above is accessed. Output appears on a Wylbur file (COAST.OUT) and intermediate scratch tape files can be accessed for debugging purposes. There are a few steps involved in running (COAST.EXEC). One must first put (COAST.EXEC) in work mode. This step is explained in Wylbur user's guide, Appendix C1D. The data file name in line 12 must then be changed to the name of the data file for which the coastdown time between 55 and 45 mph is wished. This is done using the change command in Appendix C1D.

Once this step is complete the command RUN is typed in, the return button pressed and your JOB number and JOB status will be displayed. The printed results are obtained on the 15th floor.

Source listings are included in Annex C. Also included is a sample input deck which lists the converted input file and the corresponding output files including scratch files. Any unexplained errors may be resolved with the help of the EDP (electronic data processing) people on the 14th floor.

4. Test Procedure

The following test procedure closely follows the EPA recommended practice (4). Anyone performing this test should be familair with the EPA Advisory Circular 55B. The following test procedure has been prepared to use at the Transport Canada Test Centre at Blainville, Québec.

4.1 Vehicle Preparation

The car to be tested should be in good overall condition. Checks should be made to ensure that there are no problems which could invalidate coastdown tests. These tests include wheel misalignment and brake drag. The tires should be checked to ensure that they have been broken in for at least 100 km at recommended tire pressure. Further, tires must have at least 50% of the original tread remaining. If the vehicle has been idle for more than two weeks, it should be exercised. The recommended procedure is to drive the car over 8 of the 11 laps in the Durability Driving Cycle (5) excluding laps 2, 5, and 7.

4.2 Instrumentation

The instrumentation to be installed in each vehicle for the purpose of this test include a Fluke Model 2240A data logger, a nucleus 5th wheel, and a TRIPPLITE frequency controlled DC to AC Powerverter. The data logger and powerverter are obtainable through Ken Miller at the Brock Building.

The data logger is programmed to sample the fifth wheel analog output at a rate of once every 3 seconds. The data is printed as it is collected. This arrangement is convenient and adequate for a short series of tests. However, for a longer series of tests, the manual transposition of voltage readings from the paper tape to punched computer cards will be cumbersome. In this event a cassette tape system should be designed to record the data logger output. This would require a cassette tape interface for the data logger and the capability of writing the contents of the tape created onto a computer tape. In addition to a reduction in manual effort, the cassette interface would allow the data logger to sample at the limit of it's speed; one sample per second. A summary users guide for Data Logger use during coastdown testing can be found in Appendix A4 of Annex A.

Sample data sheets for recording voltage U.S. time data may be found in Appendix A5 of Annex A.

The fifth wheel should be mounted on the rear bumper in the usual manner; the analog input should be connected to the first channel of the data logger, and the digital output to the fifth wheel display connections. These latter are used to check for proper operation of the fifth wheel after installation.

Ensure that the fifth wheel analog output calibration is available. If it is not then perform the following calibration procedure. Fully instrument a vehicle as for a coastdown test. Drive the vehicle at constant speeds in 10 Km/h (5 mph) increments according to the fifth wheel digital readout. When the vehicle is stabilized at each speed, print the analog voltage as sampled by the data logger. Obtain readings on either side of the intended steady speed. Calculate the average of the voltages at each stabilized speed taking care to discard any unreasonable readings. Fit a straight line to the resulting averages to obtain the calibration in km/h per volt (mph/volt). As an option, it may be possible to calibrate the analog output using the fifth wheel calibration machine. Sample data of an on track fifth wheel calibration can be found in Appendix A6 of Annex A. The obtained calibration factor (mph/v) is the value assigned to CALIB in the conversion program (COAST.DATA.CONV).

The TRIPPLITE poweverter should be connected directly to the battery (since the fifth wheel instruments use the lighter car accessory socket). The frequency should be adjusted to 60 HZ ±0.1% or better with the engine idling, transmission in neutral, clutch engaged. Also, any equipment which will be in use during the test such as lights, heater or instruments shall be switched on. The object is to ensure good accuracy by calibrating under the same circumstances as will be prevalent during the sampling portion of the test. It is critical that this calibration be performed since the sampling rate accuracy is dependent on the data logger time base which is synchronized with the line frequency.

4.3 Ambient Conditions

The weather conditions must be within acceptable limits during each coastdown test. The wind must be below a steady 16 km/h (10 mph) and peaks must be less than 24 km/h (15 mph). For the purposes of the analysis, steady winds along the direction of the test track are preferred. The temperature limits are from 5°C (41°F) to 35°C (95°F) and the barometric pressure from 104 KPa (31 in. Hg.) to 91 kPa (27 in. Hg.). Also the track must be dry and clear.

A sample ambient conditions and vehicle specifics data sheet may be found in Appendix A7. Data conversion from S.I. to British units may be found in Appendix A8. British units are necessary for successful program execution. Track layout and information to determine wind direction in degrees from front vehicle may be found in Appendix A9.

The weather instruments installed beside the low speed track shall be used to measure the required weather conditions. Obtaining the weather information from Mirabel Airport is inadequate because the instruments are located too far from the test track.

4.4 Test Area

Two tracks are suitable for use at the Motor Vehicle Test Centre for this procedure; the low speed and the high speed test tracks (See Appendix D). The low speed track was used for the tests performed for this report. All runs were made while running counter-clockwise and so paired runs were made on different sections of the track travelling in opposite directions. This is significantly easier than trying to make all runs on the same section of track and is suitable because the two sections of track are parallel and reasonably close together. When the low speed section of track is used, ensure that the high speed portions of the coastdown runs occur on a straight section of the track. Also, due to the 100 km/h speed limit on the low speed track, the speed must be kept below this until just before the coastdown where the speed is brought up to 110-120 km/hr. A more suitable alternative would be to use the high speed track where the speed limit is 120 km/hr. However, this track is somewhat shorter and a little more difficult to schedule. An elevation of these tracks was done for future reference and possible inclusion in the program. It may be found in Appendix D2.

4.5 Test Track

Prepare the car by filling the fuel tank and checking the tire pressure. The tires should be checked at outside ambient temperature. The pressure may be adjusted in the lab by applying the following correction factor derived from the perfect gas law.

$$P = -\frac{Pa + PM}{459 + Tg}(Ta - Tg)$$

where Pa (Psig) = Absolute Atmospheric Pressure
PM (Psig) = Manufacturer's Specification
Ta (^{o}F) = Ambient Temperature
Tg (^{o}F) = Garage Temperature

Switch on all instruments and check for their proper functioning. Check the fifth wheel, ensure that the datalogger is programmed properly, and set the built-in clock. The datalogger should sample the first channel (Channel 00), once every three seconds for paper tape output and once every second when the cassette output option is used. Warm the vehicle for 30 minutes at 80 km/h on the test track.

Obtain and record the ambient temperature and pressure.

Roll up all windows before attempting any test. Perform at least five (5) pairs of coastdown tests, and more when the ambient conditions are marginal. A pair consists of two consecutive runs in opposite directions. For each test accelerate smoothly to 110-120 km/h (65-70 mph) along the curved section of track. As the vehicle approaches the straight, shift into neutral, clutch engaged (if present), and start data collection once the vehicle has stabilized. Try to ensure that the first data point is above 100 km/h (60 mph). Stop collecting data once the speed is below 30 km/h (20 mph) ensuring that at least 60 s. of data are collected below 100 km/h (60 mph). Get the wind speed and direction for this run and reset the run identification number for the next run. As an option, have the wind data recorded continuously on an oscillograph during the test. Repeat the above procedure until five (5) or more valid run pairs are obtained. At present only hourly weather recordings are made by the control tower so that the most appropriate readings must be used.

At the conclusion of the test, record the total vehicle weight and the front-to-rear distribution with the driver and all equipment on board.

The data logger output must be transferred to computer tape either manually from paper tape, or through a cassette tape interface, depending on the system in use. This data is processed as already discussed and the appropriate dynamometer coastdown time is calculated.

4.6 Dynamometer Test

Before attempting to test the vehicle on the dynamometer, ensure that it has not been idle for an extended period of time. If so, exercise the vehicle as mentioned under vehicle preparation for track testing.

Weigh the car to determine that the unloaded weight is within 100 lb. (45 kg) of the curb weight at 40% fuel fill, and that the driving axle weight is correct to within 50 lb. The reason for using 40% fuel fill is to ensure the car is at the approximate weight as that checked by EPA after emissions testing.

Mount the vehicle on the dynamometer observing all regular procedures. Ensure that the necessary safety equipment (chocks, safety chains, tiedowns, etc.) and other necessary equipment (cooling fans, drivers aid, etc.) are installed. Ensure that no excessive loading is placed on the driving wheels due to the tiedowns. Inflate the tires to 45 psi. Connect all auxiliary fuel supply to avoid any variance in vehicle weight. Select the appropriate inertia weight and an estimated RLHP setting allowing for the dynamometer friction.

Warm the vehicle by driving two highway fuel economy test cycles. Begin coastdown testing within one minute of completing warmup.

Accelerate at the approximate rate of 3 kph/s (2 mph/s) to 100 km/h (60 mph) and coastdown in neutral, clutch engaged, to below 45 mph. The time required to coastdown from 55 to 45 mph is available from the coastdown timer installed on the dynamometer.

The purpose of this final phase of coastdown testing is to match the dynamometer load, as indicated by the PAU setting, to the on-road load through the matching of the coastdown times. To begin, choose an appropriate PAU setting close to the expeted result. Take at least three (3) readings at this point and calculate the average. Adjust the PAU setting in 0.5 HP increments and again obtain an average coastdown time. Continue this until there are two (2) readings on either side of the target coastdown time. Fit a parabola of the form:

$$HP \quad a + b\Delta t + c\,(\Delta T)^2$$

to the results obtained. The correct HP can be read from a graph or by resubstituting the target coastdown time in the above equation. The Road Load HP is the sum of that found above and the dynamometer friction HP reported to the nearest 0.1 HP.

5. Results

For the purposes of this study, testing proceeded despite unacceptable conditions. This was in an effort to gain more experience to prepare a suitable test method. Also, the weather instruments at the Test Centre were inoperative, and thus the weather was obtained from Mirabel Airport. This resulted in a degree of inaccuracy with regard to the weather information. For this reason, the wind speed and direction were obtained only once per test, along with the temperature and pressure. Further, the DC to AC converter was not adjusted to within 0.1% accuracy. It was as much as 2% out. Due to the above, the results contained herein must be considered as samples since their absolute validity is in question.

Data for the cars tested is shown in Annex 1 (Tables 1 and 2).

Of the four cars tested in this program, one was excluded from further testing due to excessive variability in the track results. This may have been caused by the high winds during the test. All of the remaining vehicles obtained RLHP readings very close to the manufacturer's estimate. The AMC Spirit turned out particularly well, despite the fact that the manufacturer's estimate was obtained using the formula method. This simply implies that the Spirit is a very "typical" vehicle. Both the Accord and the Mustang returned values better than the manufacturers' estimates.

6. Conclusions

The computer program developed by EPA to analyse coastdown data has been successfully adapted to the Transport Canada Computer and has been verified with EPA.

The facilities are available at the Test Centre to perform coastdown testing. Most of the instrumentation is at the Test Centre (including fifth wheel and DC-AC Converter), while the Fluke 2240A data logger is available from the Brock Building in Ottawa.

The testing produced reasonable results although more attention needs to be given to details such as the weather instruments and restrictions to ensure valid test results.

7. Recommendations

Before any valid tests can be performed, the weather instruments in the tower must be operative. If this is not possible, then portable weather instruments should be used.

A rapid check of the PAU setting can be made if the manufacturers were to make the dynamometer coastdown times available for each vehicle. Each car chosen for fuel economy could be coasted down on the dynamometer at the appropriate inertia weight and PAU setting. This testing could take place after the final highway fuel consumption test. If the submitted and tested coastdown times are significantly different then a complete series of coastdown tests could be initiated.

Efforts should be made to convert the coastdown program to metric units. Currently, the input data, the internal calculations and final output are in the Imperial system of units.

It is recommended that the manufacturers be requested to submit the dynamometer coastdown time for each vehicle. These times can be easily checked for every vehicle that is tested for fuel economy or emissions.

8. References

1. R.A. White and H.H. Korst, The Determination of Vehicle Drag Contribution from Coastdown Tests, SAE 720099

2. EPA Recommended Practice for Determination of Vehicle Load, OMSAPC Advisory Circular No. 55B, Attachment 1, Dec. 6, 1978

3. Coastdown Procedure for Determining Alternative Dynamometer Road Load Horsepower Setting, Ford Motor Co., Automobile Emissions and Fuel Economy Office Procedure No. AEFEO-334, effective 5-16-77

4. Determination and Use of Alternative Dynamometer Power Absorption Values, OMSPAC Advisory Circular No. 55B, Dec. 6, 1978

5. Motor Vehicle Safety Test Methods, Chapter IV, Section 1101-Vehicle Emissions, Approved 1 Sept. 1974., Appendix D

6. Guidelines for Determination and Submission of Fuel Consumption Data, Model Year 1981

ANNEX A

DATA TABLES

Appendix

A1 Table 1 - Vehicle Data
A2 Table 2 - Weather Conditions
A3 Table 3 - Equivalent Test Weights
A4 Summary Data logger User's Guide
A5 Voltage Data Sheet
A6 Sample 5th Wheel Calibration
A7 Ambient Conditions Data Sheet
A8 Data Conversion - S.I. To Imperial Units
A9 Track Layout and Information To Determine Wind Direction

APPENDIX A1 VEHICLE DATA

VEHICLES	980 VW JETTA	1980 FORD MUSTANG	1980 HONDA ACCORD	1980 AMC SPIRIT
TC No.	70-055	7102-9	70-056	70-053
Inertia Wt. Class. (lbs)[1]	2250	2750	2500	3000
Equiv. Test Wt. (lbs)[1]	2250	2875	2500	3250
Curb. Wt. FR/RR (lbs)[2]	1260/820	1506/1126	1254/878	1730/1245
Wt @ 40% Fuel Fill (lbs)[3]	1260/770	1506/1076	1254/828	1730/1198
Actual Test Wt (lbs) after track test	1340/940	1520/1180	1340/1000	1840/1420
Before dynamometer test	--*	1510/1095	1260/860	2060/1235
Manufacturer's RLHP (HP)	7.5	8.5	8.0	11.0
Target Coastdown Time (s)	--	14.531	12.318	12.148
Observed Coastdown time (s)	--	14.51	12.35	12.12
Friction HP at Equiv. Test Wt. (HP)	--	1.81	1.52	1.68
Observed HP	--	5.0	5.4	8.9
Total HP	--	6.8	6.9	10.6

* The track results for the VW Jetta were too variable to give valid results. No coastdown time was generated and thus no dynamometer matching was performed

[1] Inertia Weight Class[1] and the "Equivalent Test Weight" are derived from the table of Section 10.1.2 of the "Guidelines for Determination and Submission of fuel consumption data" (6) based on the vehicle curb weight.

[2] Curb weight is the unloaded vehicle weight with rated capacities of all fluids.

[3] Weight with 40% fuel fill is determined by subtracting the weight of 60% fuel tank capacity from the rear wheel curb weight. This was estimated to be approximately 50 lbs. for each of the cars in this sample.

APPENDIX A2

TABLE 2

WEATHER CONDITIONS

VEHICLE	VW JETTA	FORD MUSTANG	HONDA ACCORD	AMC SPIRIT
Date of Test	Sept. 23/80	Sept. 25/80	Sept. 23/80	Oct. 1/80
Time of Test	11:00	10:00	16:00	11:00
Ambient Conditions:				
Temperature (°C)	16°C	7°C	13°C	8°C
Wind Speed	26 km/hr	9 km/hr	22 km/hr	11 km/hr
Direction:	NW (105/75)	NE (15/165)	NW (90/90)	ENE (0/180)
Pressure:	99.89 KPa	101.12 KPa	100.44 KPa	100.21 KPa
Humidity:	55%	81%	47%	93%

10.1.2 The following table shall be substituted for the one in paragraph 8.7.4 of the Emission Test Methods.

Flywheels, electrical or other means of simulating test weight as shown in the following table shall be used. If the equivalent test weight specified is not available on the dynamometer being used, the next higher equivalent test weight (not to exceed 250 pounds) available shall be used.

Road Load power at 50 mi/h - trucks[1] [2] [3]	Loaded vehicle weight (pounds)	Equivalent test weight (pounds)	Inertia weight class (pounds)
	Up to 1,062	1,000	1,000
	1,063 to 1,187	1,125	1,000
	1,188 to 1,312	1,250	1,250
	1,313 to 1,437	1,375	1,250
	1,438 to 1,562	1,500	1,500
	1,563 to 1,687	1,625	1,500
	1,688 to 1,812	1,750	1,750
	1,813 to 1,937	1,875	1,750
	1,938 to 2,062	2,000	2,000
	2,063 to 2,187	2,125	2,000
	2,188 to 2,312	2,250	2,250
	2,313 to 2,437	2,375	2,250
	2,438 to 2,562	2,500	2,500
	2,563 to 2,687	2,625	2,500
	2,688 to 2,812	2,750	2,750
	2,813 to 2,937	2,875	2,750
	2,938 to 3,062	3,000	3,000
	3,063 to 3,187	3,125	3,000
	3,188 to 3,312	3,250	3,000
	3,313 to 3,437	3,375	3,500
	3,438 to 3,562	3,500	3,500
	3,563 to 3,687	3,625	3,500
	3,688 to 3,812	3,750	3,500
	3,813 to 3,937	3,875	4,000
	3,938 to 4.125	4,000	4,000
	4,126 to 4,375	4,250	4,000
	4,376 to 4,625	4,500	4,500
	4,626 to 4,375	4,750	4,500
	4,876 to 5,125	5,000	5,000
	5,126 to 5,375	5,250	5,000
	5,376 to 5,750	5,500	5,500
	5,751 to 6,250	6,000	6,000
	6,251 to 6,750	6,500	6,500
	6,751 to 7,250	7,000	7,000
	7,251 to 8,250	7,500	7,500
	7,751 to 8,250	8,000	8,000
	8,251 to 9,750	8,500	8,500
	8,751 to 9,250	9,000	9,000
	9,251 to 9,750	9,500	9,500
	9,751 to 10.000	10.000	10.000

APPENDIX A4

Summary Users Guide For Date Logger

Fluke Data Logger Model #2240A to be used on coastdown only.

OUTLINE:

Scan Control

Monitor - to continuously monitor one channel

Interval - dedicated and numeric key
- can use any time interval from 1 sec. to 24 hrs.
- time is from beginning of scan to beginning of next scan

Monitor Channel - selects channel to be monitored

Output Control
Printer Enable Only:

All Data - All readings recorded

Limit Data - Data recorded only when a limit is exceeded

Interval Data - one scan recorded at a pre-set interval

Data Logger Programming For Coastdown Procedure:

1. Plug data logger into A/C power source
2. Turn power key to "power on"
3. "Power/Failure" Ligh is flashing

    1 - Must set (DAY, DATE, TIME)

    a) Under "Time Entry" press "Days" button

    b) Key in the number of days which have elapsed this year

    c) Under "Data Entry" press "Enter/Step" button

    d) Under "Time Entry" press " Hr. Min. Sec." button

    e) Key in the "Hr.Min.Sec." in marine time which elapsed in the day thus far

    f) Under "Data Entry" press "Enter Step" button

- Time has now been entered

SCAN FORMAT:

a) Press "Fixed Data":
   - Key in a Tape Number
   - One should change this number after each run so that printouts are easy to keep track of .
   Press "Enter/Step" button

b) Press "First Channel":
   - choose 1st channel (0-9)
   Press "Enter/Step" button

c) Press "Last Channel":
   - choose last channel (0-9)
   Press "Enter/Step" button

d) Press "Interval":
   - choose sampling interval (1 sec. to 24 hrs.)
   Press "Enter/Step" button

e) Press "Monitor Channel":
   - choose the channel on which you wish to monitor your data; the same channel as analogue input
   Press "Enter/Step" button

Note:

To reduce any possibility of error choose 1st channel, last channel, and monitor channel all the same for coastdown purposes.

KEYBOARD PROGRAMMING

1) Press "Enable"
   - Enter address of desired channel
   - This channel should be the same as your monitor channel for coastdown purposes

2) Press "Enter/Step" button

3) Key in Desired Function or "Skip"
   - for coastdown the desired function is 40 volts

4) Press "Enter/Step" button

5) If no limits desired press "Enter/Step" and program next channel

Note:
- for coastdown purposes no limits are required
- after desired function is keyed into monitor channel and "Enter/Step" key has been pressed then press "Program/List" key and program is entered

6) Turn power key to "Keyboard Program Disable" and program may not be changed.

APPENDIX A5 COASTDOWN DATA:

Test Date: ________________ ( )

VEHICLE: ____________________ TC# __________ LIC# ____________

RLHP ____________ TIME: ______________ (for weather)

RUN#: ______________
Track Section: N/F
Sample Interval: _____s
Start Time: _________

RUN#: ______________
Track Section: N/F
Sample Interval: _____s
Start Time: _________

RUN#: ______________
Track Section: N/F
Sample Interval: __s
Start Time: _________

VOLTS (V)	SPEED (MPH)	VOLTS (V)	SPEED (MPH)	VOLTS (V)	SPEED (MPH)

N = near side = α1

APPENDIX A6

5TH WHEEL CALIBRATION

The vehicle should be run at 5 mph increments according to the 5th wheel digital readout. The 5th wheel analog output as interpreted by the DATA LOGGER was recorded at 20 second intervals while maintaining a steady speed.

For an exercise this calibration was done at 10 MPH increments.

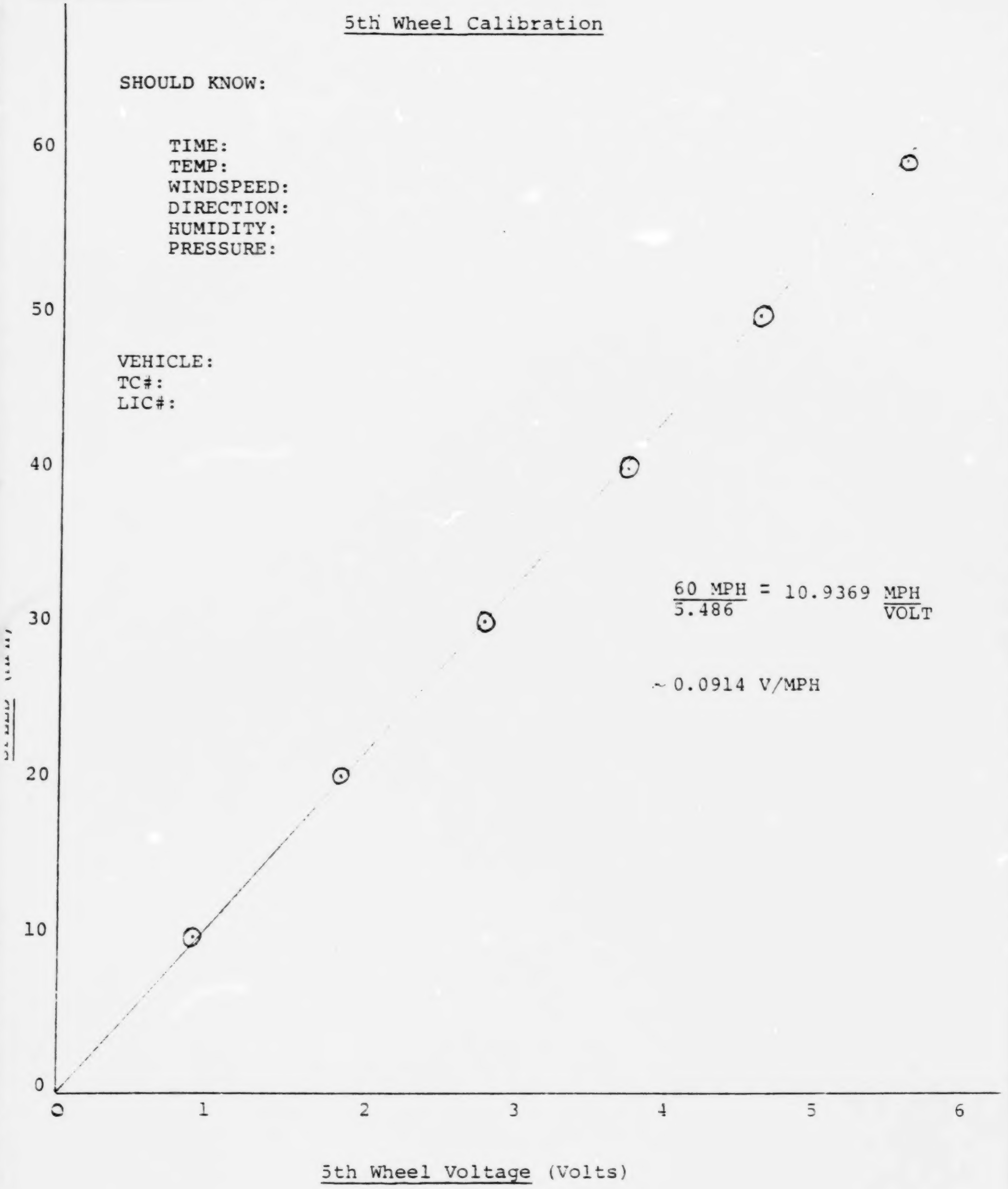
This calibration may also be done in 10 KPH increments to determine a conversion factor in KPH/volt and the converting the units to MPH/volt by

$$\mathrm{KPH}/_{\mathrm{volt}} \times 0.6214 = \mathrm{MPH}/_{\mathrm{volt}}$$

Data is as follows in the following pages.

60 MPH:	5.526 V	
	5.432 V	
	5.404	
	5.484	Avg.
	5.469	(5.4864) V.
	5.542	
	5.549	
	5.532	
	5.460	
	5.466	
50 MPH:	4.603	
	4.564	
	4.581	
	4.630	
	4.604	Avg.
	4.576	(4.551)
	4.605	
	4.570	
	4.225	
40 MPH:	3.597	
	3.686	
	3.613	
	3.689	Avg.
	3.687	(3.663)
	3.698	
	3.668	
	3.666	
30 MPH:	2.765	
	2.790	
	2.739	
	2.785	Avg.
	2.760	(2.7668)
	2.795	
	2.788	
	2.717	

20 MPH:	1.865	
	1.876	
	1.846	
	1.857	Avg.
	1.741	(1.8133)
	1.909	
	1.736	
	1.741	
	1.749	
10 MPH:	0.821	
	0.874	Avg.
	0.826	(.8842)
	0.811	
	0.839	
0 MPH:	0 volts	



5th Wheel Calibration

SHOULD KNOW:

TIME:
TEMP:
WINDSPEED:
DIRECTION:
HUMIDITY:
PRESSURE:

VEHICLE:
TC#:
LIC#:

$$\frac{60\ \text{MPH}}{5.486} = 10.9369\ \frac{\text{MPH}}{\text{VOLT}}$$

~ 0.0914 V/MPH

5th Wheel Voltage (Volts)

APPENDIX A7

DATE: ______________________
( )

COASTDOWN TEST

PAPER TAPE # ______________________

VEHICLE: ______________________

TC # ______________________

LICENSE # ______________________

RLHP ______________________

CURB WEIGHT: ______________________

INERTIA WT. CLASS: ______________________

EQUIV. TEST WT.: ______________________

WEATHER: TIME TAKEN: ______________________

TEMP: ____________ WIND SPEED: ______________________

DIRECTION: ______________________

PRESS: ____________ HUMIDITY: ______________________ %

CHECK TIRE PRESSURES : ☐

WARM UP CAR: 30 MIN @ 80 km/h ☐

RUN #	PAPER TAPE #	SECTION OF TRACK
1	______ 001	α1
2	______ 002	α4
3	______ 003	α1
4	______ 004	α4
5	______ 005	α1
6	______ 006	α4
7	______ 007	α1
8	______ 008	α4
9	______ 009	α1
10	______ 010	α4

WEIGHT FRONT: ________

W/DRIVER REAR : ________

TOTAL: ________

APPENDIX A8

Temperature:

$$\text{Deg F} = \left({}^{\circ}\text{C} \times \frac{9}{5}\right) + 32$$

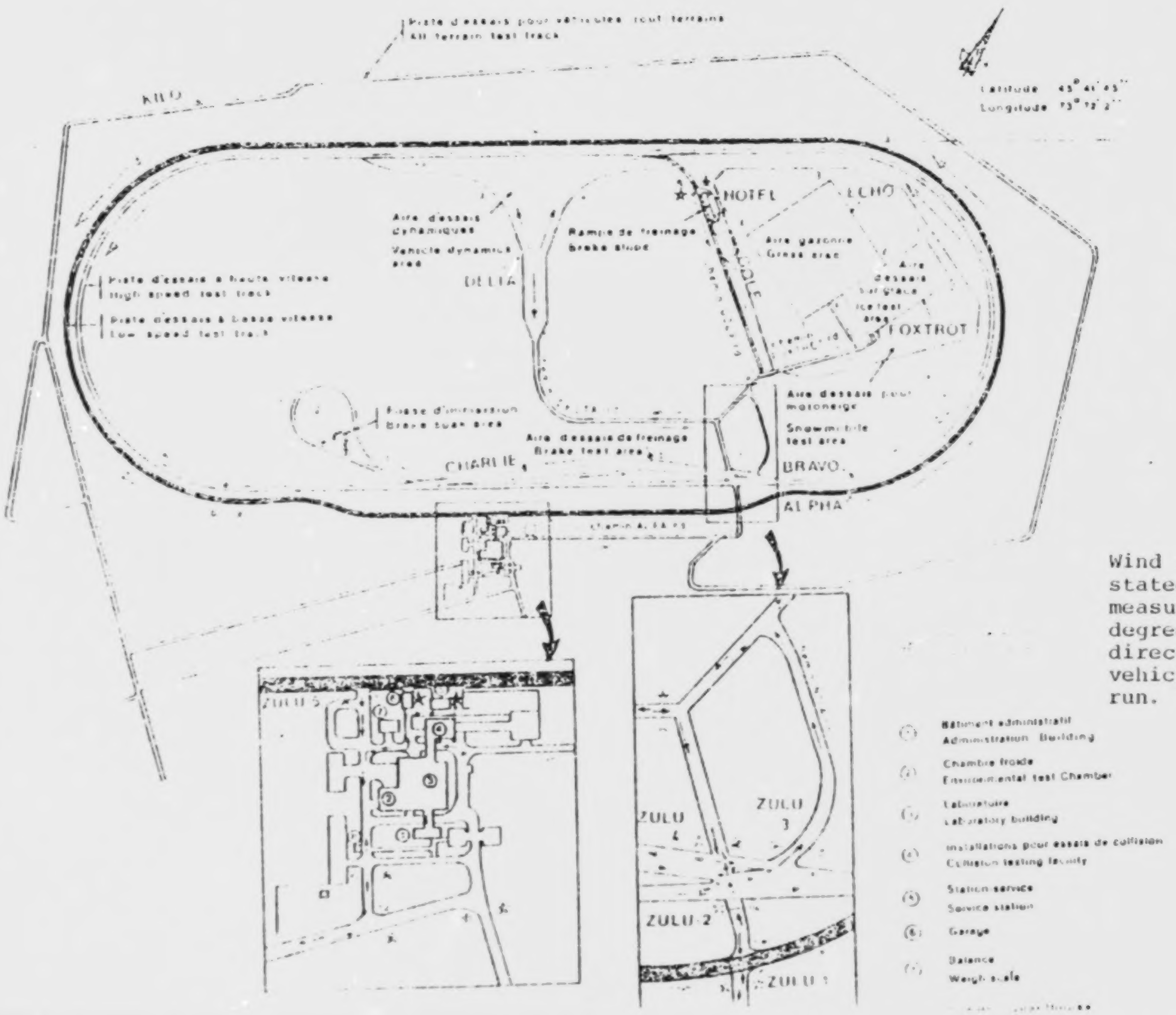
Pressure:

$$\frac{\text{kPa}}{3.36} = \text{inches of Hg.}$$

Speed:

KPH X 0.6214 = MPH

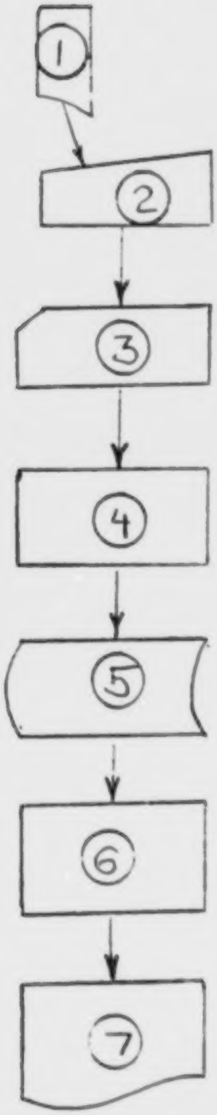
TRACK LAYOUT


Piste d'essais pour véhicules tout terrains
All terrain test track
KILO
Latitude 45° 41' 45''
Longitude 73° 12' 2''
HOTEL
ECHO
Aire d'essais dynamiques
Vehicle dynamics area
Rampe de freinage
Brake slope
Aire gazonnée
Grass area
Aire d'essais sur glace
Ice test area
DELTA
Piste d'essais à haute vitesse
High speed test track
Piste d'essais à basse vitesse
Low speed test track
FOXTROT
Aire d'essais pour motoneige
Snowmobile test area
Piste d'immersion
Brake soak area
Aire d'essais de freinage
Brake test area
CHARLIE
BRAVO
ALPHA
ZULU 5
ZULU 4
ZULU 3
ZULU 2
ZULU 1
Bâtiment administratif
Administration Building
Chambre froide
Environmental test Chamber
Laboratoire
Laboratory building
Installations pour essais de collision
Collision testing facility
Station service
Service station
Garage
Balance
Weigh scale

Wind is from the stated direction & measured in # of degrees from the direction of the vehicle on each run.

ANNEX D

SYSTEM FLOW CHART



1. Fifth wheel data is transcribed to paper tape by the datalogger.

2. Paper tape data is manually keypunched to 80 column computer cards.

3. There are 9 Header cards to a data set followed by 50 to 100 more data cards.

4. Program COAST.DATA.CONV is executed which converts the input data into formatted input files.

5. Data is formatted into temporary Wylbur files.

6. Program COAST.EXEC is executed which invoked program COAST.SOURCE ano COAST.WRITE. These programs produce output listings.

7. Output listings give speed, data analysis, and regression analysis.

ANNEX C

COMPUTER PROGRAMS

Appendix	
C1A	Brief users guide and input data description
C1B	Format Code Explanations
C1C	Sample Coding Form
C1D	Summary Wylbur Users Guide
C2	Sample raw data
C3A	COAST.DATA.CONV - Data Conversion Program Source
C3B	Explanation of Codes
C4	COAST.DATA 056 - Sample Input Data and Output
C5	COAST.SOURCE - Program Source
C6	COAST.EXEC - JCL to run coastdown program
C7	COAST.WRITE - Program to dump intermediate files
C8	SPEED, FILE 09, REGRESS - Sample intermediate scratch files

APPENDIX C1
OF ANNEX C

BRIEF USERS GUIDE

1. Purpose of Procedure

Fuel economy projections are based on dynamometer tests. The dynamometer PAU must be set so as to simulate the effect of air resistance. The required setting may be determined by either "cookbook" methods or by testing. If a vehicle is allowed to "coastdown", the air resistance may be obtained from the time dependence of its velocity. The coastdown program is used to analyze this time dependence. Factors such as vehicle weight, wind speed, humidity and temperature must be taken into account.

Some tracks are too short for a coastdown time to be determined from a single run. It is necessary to combine high and low speed coasts to form a "split" run. This program is capable of analyzing split runs.

Some effects depend on the direction of the run and can be averaged to zero by considering equal numbers of runs in both directions. For this reason, runs in opposite directions are grouped in pairs. A pair of straight runs would just be two coastdowns in opposite directions while a pair of split runs would be four coastdowns, two in each direction.

11. Language

The programs are written in standard Fortran-IV and can be run on any system with a suitable compiler. No special subroutines are required and single precision is used throughout.

111. Computer Programs

The included programs exist on Wylbur account E91.E7025C. It is possible that they have been automatically archived. To reload any one of them uses the following macro.

```
CALL FROM PUBLIC.MACROS:$RLD
```

Following the computer response, "a" should be typed in for "archive", followed by the Data Set Name (DSN) for each of the required files as follows:

DSN	Contents
COAST.DATA.CONV	Data Conversion Program Source Statements
COAST.DATA 056	Sample Input and Output Data
COAST.SOURCE	Program Source Statements
COAST.EXEC	Job Control Language to run coastdown program
COAST.WRITE	Program to dump intermediate files

IV. File Codes

The program uses several file codes. A tabular summary follows:

File Code	Purpose
05	Auxiliary file used by program to store velocities
06	Main Output
08	Input: Test Description
09	Output: Least Squares Fit Information
14	Input: Velocities for Low Speed Coastdown
15	Input: Velocities for High Speed Coastdown
16	Output: Regression Coefficients

V. Data Files

The coastdown program requires two types of data file; a test description file and one or two velocity files. The test descriptioon file(code 08) contains information such as the vehicle, the temperature and the number of runs. A velocity file (code 14 or 15) contains coastdown velocities at one second intervals. If the file contains velocities from high speed coastdowns, the data is read from file code 15. Low speed data is read from code 14. Only the "high speed" data is needed for a straight run.

Description of Header Data

The data may be stored in 80 column card format. The following table gives the position and format of each item. The format notation is standard fortran notation, A-alphanumeric, F-floating point, and l-integer.

Line-Item	Description	Columns	Format
1-1	Test I.D.	1-6	16
1-2	Manufacturer	16-30	7A2, Al
1-3	Vehicle Make	31-45	7A2, Al
1-4	Body Style	46-60	7A2, Al
2-1	Tire Size	1-15	7A2, Al
2-2	Tire Code	17-18	12
2-3	Tire pressure; Front/Rear Recommended	20-25	2F3.0
	Front/Rear Actual	27-32	2F3.0
2-4	Driving Axle Weight During Test	33-38	F6.0
2-5	Test Weight	39-44	F6.0
2-6	Equivalent Inertia Driving Wheels	45-50	F6.0
2-7	Total Equivalent Inertia	51-56	F6.0
2-8	Inertia Weight Class	57-62	F6.0
3-1	Test Date	1-6	312
3-2	Time	8-11	212
3-3	Ambient Temperature (deg. F)	13-16	F4.0
3-4	Barometric Pressure	18-22	F5.2
4-1	Number of Pairs of Runs	1-3	13
5-1	Wind Magnitude	1-80	20F4.1
6-1	Wind Direction	1-80	20F4.0
7-1	Number of Points Per Run	1-30	1013
8-1	Data Identification Card	1-80	20A4
9-	Voltage/Speed Data		

Voltage Data should be in columns 1-72 in the format 12 F6.3. Speed Data is output from the Conversion Program and must be submitted to the coastdown program under the format 12 F6.2.

Notes:

Line 2: Vehicle Description

2-6 Inertia equivalent to the rotational inertia of the driving wheels (lbs.)

2-7 Inertia equivalent to the rotational inertia of all four wheels (lbs.) (3.5 percent of total vehicle mass)

If one does not know either the equivalent inertia of the driving wheels or the total equivalent inertia, replace there inputs by (0.) and the program will automatically calculate representative values for each input.

Line 4: Number of Pairs of Runs

Each pair of runs consists of two runs; one in each direction. Thus a pair of straight runs consists of two coastdowns while a pair of split runs consists of four coastdowns. There may be up to ten pairs of runs. Pairs of split and straight runs may not be mixed.

Line 5: Wind Magnitude (mph)

Each split run is associated with a pair of wind magnitudes; one for the high speed coastdown and one for the low speed coastdown. The format of the line is:

WH(1) WL(1) WH(2) WL(2) ..... WH(N) WL(N)

where:

WH AND WL are high and low wind speeds and,
N is the number of run pairs.

For straight runs there is only one wind magnitude for each run. In this case the format is as above but the high and low speed wind magnitudes are both set equal to the actual wind magnitude.

Line 6: Wind Direction

Each of the wind magnitudes described above is associated with a wind direction. The wind direction is given in degrees from the direction of the track. A head wind could thus have a direction of 0 or 180 degrees. It does not matter which is chosen but the angles should be consistent from run to run.

Line 7 and 8: Number of Velocity Values Per Coastdown

Each split run is associated with two sets of velocity values; one set for the high velocity coastdown and one set for the low velocity coastdown. The number of points in each set must be given in the same order as the wind magnitudes. The order should also correspond to the velocity data in the data file.

A straight run is treated as a split run with no velocity values for the low speed coastdown.

7-1 The number of points per run is equal to the number of samples which were take at 3 second intervals, times 3 because the main program calculates at 1 second intervals; zeros are substituted for the other input; minus 2 because the last sample does not have two seconds following it.

Format Code Explanations

The column restriction speaks for itself, implying that for the entry stated, the figures must remain within the restrictions while still complying with the format codes.

1. Any format code with an "A" in it means the input is alphanumeric. One must merely write the required information within the column restrictions. This information is intended for retention only to help the user in identification. It is not necessary for calculations

2. Any format code with an "I" in it means "integer". eg. (I2) The 2 means there is space for 2 integers to be entered.

   If, for example, the data you wish to enter must be within columns 1 and 3, the format code states "I3", meaning three (3) integers may be entered; but you only have one. This integer must be placed in the rightmost column, the third column, or else a 0 will be read in for every column not filled to the right of your entry; meaning the computer will read a "50" or "500" instead of "5", which was intended.

   If there is a value in front of the "I", i.e. "3I2", it means there are 3 separate entries, each possibly a two (2) integer entry.

3. Any format code with an "F" in it means it is a "real number" eg. (F3.1). The 3 means that three (3) columns are alloted for your input. Of these three one must be after the decimal point, one is for the decimal point and one must be before the decimal point.

   Again, if there is a number in front of the "F", ie. (20F4.0) as in this case, it would mean that the next twenty (20) inputs would have no numbers after the decimal, that the decimal would be in the rightmost column and there is room for three more numbers, although three are not necessary, to the left of the decimal

   In this type of format the decimal must always be present even if the input is (0.).

APPENDIX C1C

IBM

FORTRAN CODING FORM

Form GX09 0011 6 U/M050
Printed in Canada

PROGRAM COASTDOWN DATA PLY. HORIZON
PROGRAMMER MIKE BRENNAN
DATE Jan 26/81
PUNCHING INSTRUCTIONS GRAPHIC PUNCH
PAGE 1 OF 4
CARD ELECTRO NUMBER*

FORTRAN STATEMENT

```
//COAST    JOB (E7025,E9100000,2800,C,2,5),'M BRENNAN 3-4981'
//STEP     EXEC PROC=FTG1CLG
//FORT.SYSIN   DD DSN=E91.E7025C.COAST.DATA.CONV,
//             VOL=SER=WYLB01,UNIT=3330-1,DISP=(OLD,KEEP),
//             DCB=(RECFM=FB,LRECL=80,BLKSIZE=3120)
//GO.FT08F001  DD *
```

* A standard card form, IBM electro 888157, is available for punching statements from this form.

IBM

FORTRAN CODING FORM

Form GX09-0011-6 U/M050
Printed in Canada

PROGRAM [illegible] DOWN DATA PLYMOUTH HORIZON
PROGRAMMER MIKE [illegible]
DATE JAN 21/81
PUNCHING INSTRUCTIONS GRAPHIC PUNCH
PAGE 2 OF 4
CARD ELECTRO NUMBER*

FORTRAN STATEMENT / IDENTIFICATION SEQUENCE

```
000330          PLYMOUTH        HORIZON         4 DOOR
155 SR13 BFG    00  29.29.  29.29. 1340. 2440.      0.      0. 2250.
01237 1 1120 45.    29.57
 5
 1.3 1.3 1.3 1.3 1.3 1.3 1.2 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3
120. 60.120. 60.120. 60.120. 60.120. 60.120. 60.120. 60.120. 60.120. 60.120. 60.
 67  0 64  0 61  0 67  0 61  0
 64  0 61  0 67  0 61  0 67  0
 VELOCITY DATA FOR COASTDOWN OF 1980 PLYMOUTH HORIZON -FDD-539
 5.522 5.142 4.793 4.507 4.233 3.972 3.720 3.512 3.318 3.128 2.946 2.770
 2.610 2.444 2.282 2.142 1.995 1.872 1.753 1.632 1.526 1.420 1.315
 5.[illegible]2 4.944 4.671 4.384 4.105 3.[illegible] 3.662 3.457 3.[illegible] 3.073 2.902 2.731
 [illegible] 2.435 2.278 2.152 2.024 1.[illegible] 1.772 1.657 1.545 1.437
 [illegible] 5.184 4.825 4.525 4.240 4.018 3.754 3.533 3.329 3.130 2.945 2.742
 [illegible] 2.426 2.262 2.113 1.962 1.843 1.721 1.596 1.480
 [illegible] 5.164 4.840 4.564 4.315 4.076 3.855 3.623 3.4[illegible] 3.240 [illegible] 2.[illegible]71
 2.72[illegible] [illegible] 2.412 2.262 2.135 1.992 1.873 1.775 1.[illegible] 1.510 1.410
 [illegible] 4.932 4.[illegible] 4.351 4.[illegible] [illegible]2. 3.612 3.419 3.[illegible] [illegible] [illegible] [illegible]
 2.56[illegible] 2.363 2.143 2.068 1.929 1.815 1.684 1.566 1.460
 5.263 4.941 4.651 4.389 4.129 3.896 3.687 3.461 3.289 3.098 2.937 2.760
 2.621 2.462 2.318 2.163 2.036 1.914 1.802 1.681 1.567 1.456
 5.251 4.915 4.607 4.347 4.089 3.824 3.625 3.431 3.227 3.024 2.854 2.682
 2.532 2.370 2.229 2.091 1.961 1.829 1.715 1.591 1.438
```

* A standard card form, IBM electro 888157, is available for punching statements from this form.

IBM

FORTRAN CODING FORM

Form GX09 0011 6 U/M050
Printed in Canada

PROGRAM

PROGRAMMER

DATE

PUNCHING INSTRUCTIONS | GRAPHIC | PUNCH

PAGE 3 OF 4
CARD ELECTRO NUMBER*

C COMM	STATEMENT NUMBER	CONT	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE

```
5.437 5.063 4.763 4,502 4,231 2,995 3,766 3.545 3,357 3.168 2,992 2.802
2.653 2,510 2.358 2.216 2.075 1,947 1.817 1.698 1,592 1.475 1,379
5,566 5.193 4.861 4,539 4,287 4.041 3.804 3.596 3.389 3.194 2.998 2.824
2.669 2.491 2.347 2.207 2.066 1,935 1,810 1,694 1,584
5.360 5.015 4.751 4.469 4.213 3,975 3,723 3.517 3,333 3.123 2.956 2,793
2,625 2.488 2.343 2.182 2.050 1.920 1.793 1,681 1,579 1.467 1.365
```

* A standard card form, IBM electro 888157, is available for punching statements from this form.

IBM

FORTRAN CODING FORM

Printed in Canada

PROGRAM COAST DECODE PLY. HARBOUR
PROGRAMMER M FREDMAN
DATE
PUNCHING INSTRUCTIONS GRAPHIC PUNCH
PAGE 4 OF 4
CARD ELECTRO NUMBER*

FORTRAN STATEMENT

```
//*
//GO.FT06F001 DD DSN=E91.E7025C.CCAST.DATA001,
//             VOL=SER=WYLB01,UNIT=3330-1,DISP=(NEW,KEEP,KEEP),
//             DCB=(RECFM=FB,LRECL=80,BLKSIZE=3120),SPACE=(TRK,(10,2))
//
```

* A standard card form, IBM electro 888157, is available for punching statements from this form.

APPENDIX C1D

Wylbur User's Guide

(Brief Summary)

To Sign On:

1. Set gandolf box to 22 for paper terminals,
   23 for screen terminals.
2. Turn on gandolf box and terminal.

Note: after each command the return key must be pressed

The terminal will prompt you for these first few commands:

	You Type	Press Return
Model?	33	✓
Terminal?	T33	✓
Account?	e91	✓
User?	e7025c	✓
Keyword?	CJF	✓

Now use remaining commands for your purposes

To Sign Off:

1. Type logoff clean, press return and you are then signed off.

Remaining Wylbur Terminal Commands

Resave: RSV

- replaces an old file version with a new one

Save into: SAV INTO (DSN)

- saves default data set on disk pack with (DSN)

Use from (DSN): Use FR (DSN)

- will copy data set from disk pack into working storage

Use from (DSN) Clear:

- will copy data set from disk to working storage for temperature default and erasing the previous default

SHO DSNS:

- used to print list of all permanent DSNS.

SHO TS:

- prints all including temporaries

NUM:

- will renumber the default data set
- 1st line #1 etc.

Delete Commands

531 - short form of delete
    - will erase line 531
    - type any line number followed immediately by a carriage return will erase that line

DEL 1/10 - will erase lines 1 - 10

Insert

I 24 - will prompt with line 24 or if line 24 already exists, the immediately following (24I) so that you may type a line of text to be added

Replace:

REP 24 - this will prompt you with line #24. Type a new line & carriage return. The old line 24 will be replaced with the new line

REP 24 List - will print line 24 then prompt you with #24 so that replacement may be typed. If the wrong line is printed can abort by pressing attention key.

MODIFY

M - will print each line of a data set and then print "Alters" so that the line may be modified using one of the modify characters

D	R	C	J	S
delete	replace	cancel	join	separate

M 4 - will print line 4 for alteration

M 1 4 7 - will print line 1 then 4 then 7 for alteration consecutively

M "bill" - will print each line containing the characters "bill" for modification

Change Commands

CH "bill" To "pay" in All:

- will change "bill" to "pay" wherever they appear in the default data set
- if the wrong line begins to print abort with attention key

CH "bill" To "pay" in 1/10

- will change "bill" to "pay" wherever it appears in lines 1 - 10
- the corrected lines will print as they are changed

CH "bill" to "pay" in 2 10

CH " " " " " " 2

List Commands

L L - will print the last line in default

L cur - will print current line

L Rev - will print only lines which have been revised for easy proofreading

L "bill" - will print every line will bill in it

L "bill" IN 10/L - list lines with bill in the for lines 10/Last

L 10/20 - list lines 10 - 20

Job Entry Commands

Run: This command will submit the default data to the Operating System as a batch job.
All JCL must be present

Run Fetch: After execution output will be placed in the fetch queue where it may be copied into a working data set using search & retrieval features

LOC 300 - may be used to check the status of the job numbered 300
- will respond with
  a) AWAITING EXECUTION
  b) AWAITING FETCH
  c) AWAITING PRINT etc.

"JOB NOT FOUND" may mean the job is finished

SHO JOBS - show status of all jobs on your account

SHO BLOG - will print a summary of all jobs in the system awaiting execution

Sign Off

Logoff CLN - will end your session & erase all data from working storage

Logoff INT - this command terminates your session, leaving working storage in exactly the condition you left it

SAMPLE ROW DATA

```
//COAST    JOB (E7025,(9100900),2300,C,2,5),'S LAMBERT 5-7295'
//STEP     EXEC PROC=ETSICLG                                               JOB 226
//FORT.SYSIN  DD DSN=ES1.E7025C.COAST.DATA.CONV,
//             VOL=SER=AYL001,UNIT=3330-1,DISP=(OLD,KEEP),
//             DCB=(RECFM=FB,LRECL=80,BLKSIZE=3120)
//GO.FT08F001 DD *
SSE)CC         HONDA          ACCORD
1.5 SR 13 8.5   33 24.24. 24.24. 1000. 2340.     0.     0. 2500.
1962B0 17.2)   35. 20.30

 813.813.813.813.813.813.813.813.813.813.813.813.813.813.813.813.813.813.813.8
  90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90.
  73  0 73  0 71  0 67  0 76  0
  70  0 75  0 75  0 73  0 73  0
  VELOCITY DATA FOR COASTDOWN OF 1980 HONDA ACCORD TC# 7C-656
  5.834 5.214 4.943 4.687 4.463 4.284 4.090 3.887 3.682 3.524 3.335 3.166
  3.032 2.912 2.754 2.614 2.466 2.351 2.258 2.146 2.046 1.917 1.824 1.712
  1.601
  5.747 5.413 5.104 4.849 4.602 4.359 4.145 3.938 3.744 3.574 3.395 3.216
  3.087 2.957 2.816 2.671 2.533 2.377 2.253 2.160 2.052 1.935 1.853 1.712
  1.631
  5.159 4.931 4.636 4.457 4.253 4.038 3.811 3.610 3.424 3.255 3.127 2.964
  2.828 2.725 2.556 2.447 2.310 2.184 2.081 1.964 1.850 1.752 1.633 1.527
  5.623 5.343 4.973 4.694 4.449 4.223 3.995 3.805 3.600 3.403 3.253 3.077
  2.922 2.771 2.628 2.486 2.352 2.203 2.088 2.018 1.880 1.773 1.681
  5.767 5.427 5.146 4.872 4.613 4.425 4.215 4.024 3.853 3.632 3.454 3.301
  3.166 2.963 2.845 2.704 2.524 2.438 2.286 2.204 2.095 1.976 1.847 1.750
  1.633 1.524
  5.470 5.213 4.912 4.622 4.362 4.100 3.959 3.773 3.573 3.420 3.227 3.085
  2.954 2.832 2.645 2.517 2.436 2.271 2.199 2.097 1.955 1.839 1.749 1.605
  5.733 5.425 5.165 4.881 4.629 4.370 4.212 4.000 3.799 3.616 3.425 3.252
  3.378 2.943 2.785 2.662 2.523 2.341 2.261 2.156 2.076 1.979 1.820 1.768
  5.713 5.419 5.125 4.851 4.579 4.351 4.121 3.943 3.721 3.525 3.351 3.175
  3.014 2.855 2.751 2.560 2.442 2.346 2.269 2.093 1.975 1.819 1.741 1.633
  5.882 5.533 5.233 4.973 4.695 4.435 4.261 4.070 3.829 3.614 3.418 3.285
  3.091 2.965 2.829 2.647 2.534 2.419 2.329 2.206 2.045 1.937 1.827 1.759
  1.674
  5.961 5.629 5.210 4.954 4.725 4.463 4.248 4.035 3.802 3.603 3.431 3.256
  3.121 2.938 2.801 2.657 2.541 2.396 2.235 2.161 2.107 1.904 1.775 1.645
  1.594
/*
//GO.FT09F001 DD DSN=ES1.E7025C.COAST.DATA05G,
//             VOL=SER=AYL001,UNIT=3330-1,DISP=(NEW,KEEP,KEEP),
//             DCB=(RECFM=FB,LRECL=80,BLKSIZE=3120),SPACE=(TRK,(10,2))
//
```

APPENDIX C3
TO ANNEX C

COAST DATA CONVERSION

```
C
C     PROGRAM TO TRANSFER DATA FROM PUNCHED CARDS TO
C     DATA FILE 'DATA.CARD'.  ALSO, THE 5TH WHEEL VOLTAGE
C     READINGS ARE CONVERTED TO SPEED READINGS IN MPH.
C
      INTEGER TSTRUN, IHIGH(10), ILOW(10)
      INTEGER*2 MANUF(6), MAKE(5), BSTYLE(8), TRSIZE(8),
     .          TDATE(3), TIME(2), TCODE
      REAL PRES(4), CCMM(20), WIND(40), WDIR(40), V(150)
C
C     READ IN HEADER DATA AND OUTPUT TO DATA FILE.
C
      READ (3,10) TSTRUN, MANUF, MAKE, BSTYLE
      WRITE(6,10) TSTRUN, MANUF, MAKE, BSTYLE
C
      READ(3,20) TRSIZE, TCODE, PRES, DWT, TSTWT, AR, TCTR, DYNO
      WRITE(6,20) TRSIZE, TCODE, PRES, DWT, TSTWT, AR, TCTR, DYNO
C
      READ(3,30) TDATE, TIME, TDRY, BAR
      WRITE(6,30) TDATE, TIME, TDRY, BAR
C
      READ(3,40) NPAIR
      WRITE(6,40) NPAIR
      NRUNS= NPAIR*2
      NRUNS2= NRUNS*2
C
      READ(3,50) (WIND(J), J=1,NRUNS2)
      WRITE(6,50) (WIND(J), J=1,NRUNS2)
C
      READ(3,60) (WDIR(J), J=1,NRUNS2)
      WRITE(6,60) (WDIR(J), J=1,NRUNS2)
C
      READ(3,70) ( (IHIGH(J),ILOW(J)), J=1,NRUNS)
      WRITE(6,70) ( (IHIGH(J),ILOW(J)), J=1,NRUNS)
C
      READ(3,80) CCMM
      WRITE(6,80) CCMM
C
C     READ IN VOLTAGES AND CONVERT TO SPEED.  ALSO, PAD
C     DATA TO OBTAIN READINGS EVERY 1.5 AS IS REQUIRED BY COAST
C     PROGRAM.
C     INC IS THE ORIGINAL DATA SAMPLING INCREMENT.
C
      INC= 3
C
C     CALIT IS THE CALIBRATION FACTOR CORRESPONDING TO 5TH
C     WHEEL NUMBER 4026.
C
      CALIT= 11.741
C
       DO 140 J=1,NRUNS
         IHJ= IHIGH(J)
         DO 100 I=1,IHJ
  100      V(I)= 0.
         READ(3,150) (V(I), I=1,IHJ,INC)
         DO 110 I=1,IHJ,INC
           V(I)= V(I)*CALIT
C          IF (I.EQ.1 .OR. INC.EQ.1) GO TO 110
C          IINC= I - INC
C          DIFF= V(I) - V(IINC)
C          KINC= IINC + 1
```

```
C            II= I - 1
C            DO 105 K=KINC,II
105            V(K)= V(IINC) + DIFF*( FLOAT(K-IINC)/FLOAT(INC) )
110       CONTINUE
          WRITE(6,160) (V(I), I=1,IIJ)
C
C         CHECK FOR LOW SPEED RUNS.
C
          IF (ILOW(J).LE.0) GO TO 140
          ILJ= ILOW(J)
          DO 120 I=1,ILJ
120          V(I)= 0.
          READ(8,150) (V(I), I=1,ILJ,INC)
          DO 130 I=1,ILJ,INC
130          V(I)= V(I)*CALIB
          WRITE(6,160) (V(I), I=1,ILJ,INC)
140    CONTINUE
C
       STOP
C
C      FORMAT STATEMENTS
C
10     FORMAT(I6,4X,3(7A2,A1))
20     FORMAT(7I2,I1,1X,I2,2(1X,2F3.0),5F6.0)
30     FORMAT(2I2,1X,2I2,1X,F4.0,1X,F5.2)
40     FORMAT(I3)
50     FORMAT(20F4.1)
60     FORMAT(20F4.0)
70     FORMAT(10I8)
80     FORMAT(20A4)
150    FORMAT(12F6.3)
160    FORMAT(12F6.2)
       END
```

APPENDIX C3B

Line:		
13	TSTRUN	Test I.D.
	MANUF	Manufacturer
	MAKE	Make
	BSTYLE	Body Style
16	TRSIZE	Tire Size
	TCODE	Tire Code
	PRES	Tire Pressure
	DWT	Driving Axle Weight
	TSTWT	Test Weight
	MR	Equivalent Inertia Driving Wheels
	TOTR	Total Equivalent inertia
	DYNO	Inertia Weight Class
19	TDATE	Test Date
	TIME	Time of Test
	T DRY	Ambient Temperature (°F)
	BAR	Barometric Pressure (in. Hg)
22	NPAIR	# of Pairs of Runs
24	NRUNS	NPair X 2
25	NRUNS2	NRuns X 2
27	WIND H(1), L(1), H(2), L(2)	Wind Speed (MPH)
30	WDIR H(1), L(1), H(2),L(2)	Wind Direction (degrees from direction of vehicle)
33	IHIGH	# of seconds of high speed run
	ILOW	# of seconds of low speed run
36	COMM	Comment Statement
42	INCREMENT	

APPENDIX C4
TO ANNEX C

COAST DATA 056
(OUTPUT)

```
 HONDA                                   ACCORD
1958 58  13  HC      [illegible]  24.24.  1000.  2340.     0.     0.  2500.
 [illegible]  C  -4 [illegible]
13.813.813.813.813.813.813.813.813.813.813.813.813.813.813.813.813.813.813.813.813.
 90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90. 90.
 73  0 72  0 72  0 67  0 76  0
 70  0 70  0 70  0 72  0 72  0
 VELOCITY DATA FOR COASTDOWN OF 1980 HONDA ACCORD TC# 79-056
 55.74   0.0   0.0  52.19   0.0   0.0  49.42   0.0   0.0  46.87   0.0   0.0
 44.63   0.0   0.0  42.84   0.0   0.0  40.90   0.0   0.0  38.87   0.0   0.0
 36.87   0.0   0.0  35.24   0.0   0.0  33.35   0.0   0.0  31.66   0.0   0.0
 30.32   0.0   0.0  29.12   0.0   0.0  27.64   0.0   0.0  26.14   0.0   0.0
 24.60   0.0   0.0  23.51   0.0   0.0  22.54   0.0   0.0  21.45   0.0   0.0
 20.46   0.0   0.0  19.17   0.0   0.0  18.34   0.0   0.0  17.12   0.0   0.0
 16.31
 57.47   0.0   0.0  54.13   0.0   0.0  51.04   0.0   0.0  48.49   0.0   0.0
 46.12   0.0   0.0  43.59   0.0   0.0  41.45   0.0   0.0  39.38   0.0   0.0
 37.44   0.0   0.0  35.74   0.0   0.0  33.95   0.0   0.0  32.16   0.0   0.0
 30.87   0.0   0.0  29.67   0.0   0.0  28.16   0.0   0.0  26.70   0.0   0.0
 25.31   0.0   0.0  23.77   0.0   0.0  22.53   0.0   0.0  21.60   0.0   0.0
 20.53   0.0   0.0  19.35   0.0   0.0  18.53   0.0   0.0  17.12   0.0   0.0
 16.31
 51.99   0.0   0.0  49.31   0.0   0.0  46.68   0.0   0.0  44.57   0.0   0.0
 42.53   0.0   0.0  40.33   0.0   0.0  38.11   0.0   0.0  36.10   0.0   0.0
 34.24   0.0   0.0  32.55   0.0   0.0  31.27   0.0   0.0  29.64   0.0   0.0
 28.28   0.0   0.0  27.25   0.0   0.0  25.56   0.0   0.0  24.47   0.0   0.0
 22.10   0.0   0.0  21.84   0.0   0.0  20.81   0.0   0.0  19.64   0.0   0.0
 18.50   0.0   0.0  17.52   0.0   0.0  16.33   0.0   0.0  15.27
 56.25   0.0   0.0  53.43   0.0   0.0  49.73   0.0   0.0  46.94   0.0   0.0
 44.49   0.0   0.0  42.23   0.0   0.0  39.95   0.0   0.0  38.05   0.0   0.0
 36.00   0.0   0.0  34.03   0.0   0.0  32.53   0.0   0.0  30.77   0.0   0.0
 29.22   0.0   0.0  27.71   0.0   0.0  26.23   0.0   0.0  24.80   0.0   0.0
 23.52   0.0   0.0  22.10   0.0   0.0  20.88   0.0   0.0  20.13   0.0   0.0
 18.60   0.0   0.0  17.73   0.0   0.0  16.81
 57.67   0.0   0.0  54.27   0.0   0.0  51.46   0.0   0.0  48.72   0.0   0.0
 46.13   0.0   0.0  44.25   0.0   0.0  42.15   0.0   0.0  40.24   0.0   0.0
 38.55   0.0   0.0  36.32   0.0   0.0  34.54   0.0   0.0  33.01   0.0   0.0
 31.68   0.0   0.0  29.63   0.0   0.0  28.45   0.0   0.0  27.04   0.0   0.0
 25.24   0.0   0.0  24.38   0.0   0.0  22.86   0.0   0.0  22.04   0.0   0.0
 20.95   0.0   0.0  19.76   0.0   0.0  18.47   0.0   0.0  17.50   0.0   0.0
 16.23   0.0   0.0  15.24
 54.70   0.0   0.0  52.13   0.0   0.0  49.12   0.0   0.0  46.22   0.0   0.0
 43.62   0.0   0.0  41.66   0.0   0.0  39.59   0.0   0.0  37.73   0.0   0.0
 35.73   0.0   0.0  34.29   0.0   0.0  32.27   0.0   0.0  30.85   0.0   0.0
 29.54   0.0   0.0  28.22   0.0   0.0  26.45   0.0   0.0  25.17   0.0   0.0
 24.36   0.0   0.0  22.71   0.0   0.0  21.99   0.0   0.0  20.97   0.0   0.0
 19.95   0.0   0.0  18.39   0.0   0.0  17.49   0.0   0.0  16.65
 57.34   0.0   0.0  54.25   0.0   0.0  51.65   0.0   0.0  48.81   0.0   0.0
 46.29   0.0   0.0  43.90   0.0   0.0  42.12   0.0   0.0  40.00   0.0   0.0
 37.99   0.0   0.0  36.16   0.0   0.0  34.25   0.0   0.0  32.52   0.0   0.0
 30.78   0.0   0.0  29.45   0.0   0.0  27.85   0.0   0.0  26.62   0.0   0.0
 25.28   0.0   0.0  23.81   0.0   0.0  22.61   0.0   0.0  21.99   0.0   0.0
 20.76   0.0   0.0  19.79   0.0   0.0  18.20   0.0   0.0  17.68
 57.13   0.0   0.0  54.18   0.0   0.0  51.25   0.0   0.0  48.51   0.0   0.0
 45.79   0.0   0.0  43.51   0.0   0.0  41.21   0.0   0.0  39.43   0.0   0.0
 37.21   0.0   0.0  35.25   0.0   0.0  33.51   0.0   0.0  31.75   0.0   0.0
 30.14   0.0   0.0  28.59   0.0   0.0  27.51   0.0   0.0  25.80   0.0   0.0
 24.42   0.0   0.0  23.46   0.0   0.0  22.09   0.0   0.0  20.90   0.0   0.0
 19.70   0.0   0.0  18.18   0.0   0.0  17.41   0.0   0.0  16.33
 58.22   0.0   0.0  55.52   0.0   0.0  52.23   0.0   0.0  49.70   0.0   0.0
```

```
46.95   0.0   0.0  44.95   0.0   0.0  42.61   0.0   0.0  40.70   0.0   0.0
38.29   0.0   0.0  36.14   0.0   0.0  34.13   0.0   0.0  32.85   0.0   0.0
30.91   0.0   0.0  29.65   0.0   0.0  28.29   0.0   0.0  26.47   0.0   0.0
25.84   0.0   0.0  24.19   0.0   0.0  23.29   0.0   0.0  22.06   0.0   0.0
20.89   0.0   0.0  19.87   0.0   0.0  18.27   0.0   0.0  17.50   0.0   0.0
16.74
59.61   0.0   0.0  56.98   0.0   0.0  53.10   0.0   0.0  49.94   0.0   0.0
47.25   0.0   0.0  44.63   0.0   0.0  42.48   0.0   0.0  40.33   0.0   0.0
38.02   0.0   0.0  36.03   0.0   0.0  34.31   0.0   0.0  32.56   0.0   0.0
31.21   0.0   0.0  29.38   0.0   0.0  28.01   0.0   0.0  26.57   0.0   0.0
25.41   0.0   0.0  23.96   0.0   0.0  22.35   0.0   0.0  21.61   0.0   0.0
20.97   0.0   0.0  19.04   0.0   0.0  17.75   0.0   0.0  16.85   0.0   0.0
15.94
```

```
                        ROAD COAST DOWN TEST
           TEST RUN NO: [illegible]
           VEHICLE :   HONDA              ACCORD
         TEST DATE :   [illegible]   AT TIME 10: 0:
      [illegible] PRES(F):[illegible]  :[illegible] & TEST PRES(F):24. & R:24.
  TIRE & RIM SIZE: [illegible]          TIRE CODE:  0

  TEST CONDITIONS
  ---------------

   AMBIENT TEMP.-F:   [illegible]
  BAROM. P. IN HG.:   [illegible]
   WT. (AFTER TEST):  [illegible]   (TOTAL)
  GIVEN AXLE WEIGHT:  1000.

   NO OF RUN PAIRS:   [illegible]

            COEFFICIENTS IN TERMS OF AC.A2 (OBSERVED)
         AC
  0.[illegible]E+00                              A2               RMS ERROR
  0.[illegible]E+00                       0.24495507E-03     0.1930E+00
  0.[illegible]E+00                       0.26255939E-03     0.1610E+00
  0.[illegible]E+00                       0.24735089E-03     0.1901E+00
  0.[illegible]E+00                       0.27521397E-03     0.1725E+00
  0.[illegible]E+00                       0.24108347E-03     0.2414E+00
  0.[illegible]E+00                       0.27205842E-03     0.2073E+00
  0.[illegible]E+00                       0.24080717E-03     0.2184E+00
  0.[illegible]E+00                       0.24832925E-03     0.1565E+00
  0.[illegible]E+00                       0.24218272E-03     0.3073E+00
                                          0.26609795E-03     0.1378E+00
      OBSERVED DATA AT TEST CONDITIONS (NO CORRECTIONS)

      OBSERVED COAST TIME     11.075

      AVERAGE COEFFICIENTS
                                                   STANDARD DEVIATIONS
      AC  =        0.271[illegible]E+00  (MI/HR-SEC)      0.1155925E-01  (MI/HR-SEC)

      A2  =        0.254[illegible]-03  (HR/MI-SEC)     0.6096014E-05  (HR/MI-SEC)
      PAIR    [illegible] HAS BEEN REJECTED DUE TO HIGH RMS

      1 PAIR(S) OF RUNS HAVE BEEN REJECTED

      OBSERVED DATA AT TEST CONDITIONS (NO CORRECTIONS BUT AFTER RMS REJECTIONS)

      OBSERVED COAST TIME     11.099

      AVERAGE COEFFICIENTS
                                                   STANDARD DEVIATIONS
      AO  =        0.[illegible]E+00  (MI/HR-SEC)      0.125124[illegible]-01  (MI/HR-SEC)

      A2  -        0.[illegible]-03  (HR/MI-SEC)      0.7037[illegible]-05  (HR/MI-SEC)

      OBSERVED COAST TIME AFTER REJECTION     11.099

      RESULTS AFTER [illegible] CORRECTIONS

      AVERAGE COEFFICIENTS                         STANDARD DEVIATIONS
```

```
AC =      [illegible]+00   (MI/HR-SEC)       0.1251246E-01   (MI/HR-SEC)
AE =      [illegible]-03   (HR/MI-SEC)       0.7037728E-05   (HR/MI-SEC)
WIND CORRECTED COAST TIME    11.095
              WEATHER CORRECTED RESULTS
WEATHER CORRECTED COAST TIME    11.736
DATA WEATHER CORRECTED TO 68 F, 29.0" HG
COEFFICIENTS
AC =      [illegible]+00   (MI/HR-SEC)
AE =      0.2411941E-03   (HR/MI-SEC)

              MASS CORRECTED RESULTS
TOTAL SYSTEM WEIGHT      2422.  LBS (TEST WT +          ROTATING EQUIVALENCES)
FORMULA INERTIAS ARE BEING USED

DRIVING ROTATING EQUIVALENT          42.
NON-DRIVING ROTATING EQUIVALENT      40.

INERTIA WEIGHT CLASS     2500.  LBS.
MASS CORRECTIONS TO      2542.  LBS. MASS

DYNAMOMETER COAST TIME(55-45 MPH)  12.318


INERTIA WEIGHT    DYNAMOMETER
CATEGORY          COAST-DOWN TIME
---------------   ---------------

    2125              10.501
    2250              11.107
    2375              11.713
    2500              12.318
    2625              12.924
    2750              13.530
    2875              14.136
```

APPENDIX 5
TO ANNEX C

COAST SOURCE

```
      REAL KG,M
C     SUBROUTINE [illegible]
C
C     THIS IS THE MAIN SUBROUTINE
      COMMON /[illegible]/ A(20,3),RMS(20),B(10,3),
     *[illegible](30),[illegible](40),S(10),NPAIR,NRUNS,NF
      COMMON /[illegible]/KR,MF,ACTUAL,DYNR,TSTWT,C1,RK3,TDRY,TEMA
      DIMENSION TOT( ),AV(3),SD(3),VMIN(3),VMAX(3)
      LOGICAL OK,ACTUAL
C
C     INITIALIZE STANDARD TEMPERATURE
      TEMA=60.
      NF=10
C     NF IS THE MAX NUMBER OF PAIRS THAT CAN BE HANDLED
      CALL INPUT
      CALL AV[illegible]
C     INITIALIZE S VECTOR FOR SUBROUTINE TALLY
      DO 10 I=1,NPAIR
      S(I)=1.0
   10 CONTINUE
      CALL TALLY(0,S,TOT,AV,SD,VMIN,VMAX,NPAIR,3,NF)
C
C     GET OBSERVED FORCES AND COAST TIME
C
      CALL TIME(AV,TOBS)
      WRITE(6,40)
      WRITE(6,30)TOBS
      WRITE(6,20)AV(1),SD(1),AV(3),SD(3)
C
C     NOW DO RMS REJECTION
      CALL REJECT(ICHECK)
C     CHECK IF PAIRS HAVE BEEN LOST THROUGH RMS REJECTION
C     IF SO RECOMPUT AVERAGE COEFS AND COAST TIME.
      IF(ICHECK .EQ. NPAIR)GO TO 50
C     RECOMPUTE AVERAGE COEFFICIENTS SINCE RUNS HAVE BEEN REJECTED
      CALL TALLY(0,S,TOT,AV,SD,VMIN,VMAX,NPAIR,3,NF)
      CALL TIME(AV,TRMS)
      WRITE(6,40)
      WRITE(6,30)TRMS
      WRITE(6,20)AV(1),SD(1),AV(2),SD(3)
C
C     NOW DO STANDARD DEVIATION REJECTION
C
   50 CALL UNIT(AV)
      CALL UNIT(SD)
      OK=.FALSE.
   60 CONTINUE
      CALL [illegible](S,AV,ICHECK,OK)
      IF(OK)GO TO 70
      GO TO 60
   70 CONTINUE
C
C     GET COAST DOWN TIME FROM OBSERVED COEFFICIENTS AFTER
C     ALL RUNS HAVE BEEN REJECTED
C
      DO 80 I=1,3
      AV(I)= AV(I)/[illegible]
   80 CONTINUE
      CALL TIME(AV,[illegible])
      WRITE(6,[illegible])[illegible]
C     CALL XWIND TO WIND CORRECT THE COEFS
```

```
      CALL XPLOT
      WRITE(6,100)
      CALL AVE(3,3)
      CALL TALLY(3,3,DT,AV,SD,VMIN,VMAX,NPAIR,3,NF)
      WRITE(6,250)AV(1),SD(1),AV(3),SD(3)
      CALL TIME(AV,TSEC2)
      WRITE(6,165)TSEC2
C
C
C     CORRECT AV FOR DENSITY
      AV(3)=AV(3)*RK1
C     CORRECT AV TERM FOR TEMPERATURE
      AV(1)= AV(1)*(1.+4.6E-3*(TDRY-TEMPA))
C
C
C     GET WEATHER CORRECTED COAST DOWN TIME
C
      CALL TIM(AV,DELTW)
      WRITE(6,110)
      WRITE(6,120)DELTW
      WRITE(6,130)
      WRITE(6,230)AV(1),AV(3)
C
C     DO MASS CORRECTION ON COAST DOWN TIME
C
      DELT= DELTW*(DYNO+MR)/(TSTWT+MR+MF)
C     GET MASS CORRECTED RESULTS
C
      WRITE(6,140)
      TMASS=TSTWT+MR+MF
      WRITE(6,150)TMASS
      IF(ACTUAL)WRITE(6,160)
      IF(.NOT.ACTUAL)WRITE(6,170)
      WRITE(6,180)MR,MF
      WRITE(6,190)DYNO
      TACOD=[illegible]
      WRITE(6,200)TACOD
      WRITE(6,210)DELT
C     CALL ICLASS TO PRINT INERTIA WEIGHT CLASS COAST-DOWN TIME TABLE
      CALL ICLASS(DELTW)
C
   20 FORMAT(//T10,'OBSERVED DATA AT TEST CONDITIONS (NO CORRECTIONS)')
   30 FORMAT(/T10,'OBSERVED COAST TIME',2X,F7.3)
   40 FORMAT(//T10,'OBSERVED DATA AT TEST CONDITIONS (NO CORRECTIONS BUT
     $AFTER WIND REJECTIONS)')
   50 FORMAT(/T10,'OBSERVED COAST TIME AFTER REJECTION',2X,F7.3)
  100 FORMAT(//T10,'RESULTS AFTER WIND CORRECTIONS')
  105 FORMAT(/T10,'WIND CORRECTED COAST TIME',2X,F7.3)
  110 FORMAT(//T25,'WEATHER CORRECTED RESULTS')
  120 FORMAT(/T10,'WEATHER CORRECTED COAST TIME',2X,F7.3)
  130 FORMAT(/T10,'DATA WEATHER CORRECTED TO 68 F, 29.92" HG')
  140 FORMAT(//T25,'MASS CORRECTED RESULTS')
  150 FORMAT(/T10,'TOTAL SYSTEM WEIGHT',3X,F6.0,' LBS (TEST WT +
     $ ROTATING EQUIVALENTS)')
  160 FORMAT(/T10,'ACTUAL INERTIA DATA IS BEING USED')
  170 FORMAT(/T10,'FORMULA INERTIAS ARE BEING USED')
  180 FORMAT(/T10,'DRIVING ROTATING EQUIVALENT',6X,F5.0,/T10,'NON-DRIVING
     $ ROTATING EQUIVALENT',2X,F5.0)
  190 FORMAT(/T10,'INERTIA WEIGHT CLASS',F9.0,2X,'LBS.')
  200 FORMAT(T10,'TAX. CORRECTION TO ',F8.0,2X,'LBS. MASS')
  210 FORMAT(//T10,'DYNAMOMETER COAST TIME(55-45 MPH)',F8.3)
```

```
   22 FORMAT(/T15,'AVERAGE COEFFICENTS',T53,'STANDARD DEVIATIONS',//
     &T10,'A0 =',3X,E16.7,2X,'(MI/HR-SEC)',T50,E16.7,3X,'(MI/HR-SEC)',
     &//T10,'A2 =',3X,E16.7,2X,'(HR/MI-SEC)',T50,E16.7,2X,'(HR/MI-SEC)')
   23 FORMAT(/T15,'COEFFICENTS',T53,//
     &T10,'A0 =',3X,E16.7,2X,'(MI/HR-SEC)',
     &//T10,'A2 =',3X,E16.7,2X,'(HR/MI-SEC)')
      STOP
      END
      SUBROUTINE AVE(A,B)
C
C     THIS ROUTINE DOES PAIRWISE AVERAGING FOR THE A0,A2 COEFFICIENTS
C
      DIMENSION A(20,3),B(10,3)
      I=-1
      DO 100 K=1,10
      I=I+2
      DO 100 L=1,3
  100 B(K,L)=.5*(A(I,L)+A(I+1,L))
      RETURN
      END
      SUBROUTINE RD
C     THIS SUBROUTINE READS IN THE RAW DATA
      DIMENSION A(300),P(3),P0(3),P1(3)
      DATA IEND/'END'/
      COMMON V0
   15 READ(5,1,END=19)IR,NC
      IF(IR.EQ.IEND)RETURN
    1 FORMAT(1X,A3,16X,I6)
    2 FORMAT (2X,F5.2,2X,F5.2)
      NC2=NC*2
      DO 3 L=1,NC2,2
      READ (5,2,END=20) A(L),A(L+1)
    3 CONTINUE
C     CALL SELECT TO REJECT DATA OUTSIDE THE 60-20 SPEED RANGE.
      CALL SELECT(A,NC)
      V0=A(2)
      L1=1+2*NC
C     SET MAXIMUM AND MINIMUM FOR FITTED PARAMETERS TO 1.0 AND 0.0.
      DO 7 I=1,2
      P1(I)=1.0
    7 P0(I)=0.
C     SET INITIAL GUESSES FOR P(1) AND P(2)
C     FORM DV/DT= -(A0+A2*V**2)
C     A0=P(1) AND A2=P(1)*P(2)**2.
      P(1)=.291
      P(2)=.0255
      CALL MINIZ(2,A(L1),P,NC,P0,P1)
      GO TO 15
   19 WRITE(13,11)
   11 FORMAT('0','*** END OF FILE REACHED ON UNIT 5 (-A) WHEN TRYING TO
     &          READ THE RUN NUMBER OR THE NUMBER OF SPEED POINTS.',/)
      GO TO 30
   20 WRITE(13,21)
   21 FORMAT('0','*** END OF FILE REACHED ON UNIT 5 (-A) WHEN TRYING TO
     &                                READ ONE OF THE SPEED POINTS.',/)
   30 STOP
      END
      SUBROUTINE FUN2(F,FP,P,T)
      REAL FP(2),P(2)
C     THE INITIAL VELOCITY V0 IS ASSUMED TO OCCUR AT TIME T=0.0
      COMMON V0
      A=P(1)
      B=P(2)
      RR=ATAN(B*V0)
      Z=TAN(RR-A*B*T)
      F= Z/B
C     FP(I) IS THE PARTIAL DERIVATIVE OF F WITH RESPECT TO P(I)
      FP(1)= -T*(Z**2+1.0)
      FP(2)= -Z/(B**2)+1./B*(Z**2+1.)*(-A*T+V0)/(1.+(B*V0)**2))
      RETURN
      END
      SUBROUTINE ICLASS(DELTD)
C     THIS SUBROUTINE COMPUTES THE MASS CORRECTED
C     COASTDOWN TIME FOR VARIOUS INERTIA WEIGHT CLASSES
C     FROM DELTD THE WEATHER CORRECTED COAST TIME
      REAL MR,MF
      COMMON /AB/ A,/AR/MR,MF,ACTUAL,DYNO,TSTWT,C1,RK3,TDRY,TEPA
      DIMENSION IWT(45)
      DATA IWT/
     &875., 1000., 1125., 1250., 1375., 1500., 1625., 1750., 1875., 2000.,
     &2125., 2250., 2375., 2500., 2625., 2750., 2875., 3000., 3125., 3250.,
     &3375., 3500., 3625., 3750., 3875., 4000., 4250., 4500., 4750., 5000.,
     &5250.,5500., 6000., 6500., 7000., 7500., 8000., 8500., 9000., 9500.,
     &10000.,10500.,11000.,11500.,12000/
C     FIND THE POSITION IN THE IWT TABLE
C     WHICH MATCHES THE INERTIA WEIGHT CLASS OF THE VEHICLE
      IDYNO=DYNO
      DO 100 K=1,45
      IPOS=K
      IF(IDYNO .EQ. IWT(K))GO TO 110
  100 CONTINUE
      WRITE(6,105)
  105 FORMAT(//T5,'THE INERTIA WEIGHT CLASS OF THE VEHICLE IS NOT
     & IN THE TABLE OF USUAL VALUES'
     &/T5,'NO  INERTIA WEIGHT COAST-TIME TABLE WILL BE GENERATED')
C     THIS IS A RETURN IF THE INERTIA WEIGHT CLASS IS NOT FOUND
      RETURN
C
  110 ISTART=IPOS-4
      WRITE(6,120)
C     PRINT COAST-DOWN TIME FOR GIVEN INERTIA WEIGHT + 3 ADDITIONAL
C     INERTIA WEIGHT CLASSES ABOVE AND BELOW.
      DO 125 L=1,7
      K=L+ISTART
      TWT=IWT(K)
      DELT=DELTD*(TWT+MR)/(TSTWT+MR+MF)
      WRITE(6,130)IWT(K),DELT
  125 CONTINUE
  120 FORMAT(///T5,'INERTIA WEIGHT',3X,'DYNAMOMETER'/T5,'CATEGORY',9X,
     &'COAST-DOWN TIME'/T5,14('-'),3X,15('-')/,' ')
  130 FORMAT(T8,I5,12X,F6.3)
      RETURN
      END
      SUBROUTINE INPUT
C
C     THIS SUBROUTINE HANDLES INPUT FROM A TTI DATA SHEET
C
      COMMON /ABC/ A(20,3),RMS(20),B(10,3),
     &WIND(40),AWIND(40),S(10),NPAIR,NRUNS,NF
      COMMON /AR/ MR,MF,ACTUAL,DYNO,TSTWT,C1,RK3,TDRY,TEPA
      REAL MR,MF,IPCS(4),COMM(20)
      DIMENSION IHIGH(20),ILOW(20)
      DATA G/32.17/,RNK/459.7/,STBAR/29.0/
      INTEGER IHIGH(20),ILOW(20),TESTRN
      INTEGER*2 IDATE(3),TIME(2),TCODE,MANUF(8),MAKE(8),BSTYLE(8),
     $TRSIZE(8)
      LOGICAL ACTUAL
C
C     GET DESCRIPTIVE INFO
      READ(8,10,END=81)TESTRN,MANUF,MAKE ,BSTYLE
C     GET TIRE PRESSURES FROM BEFORE TEST,INERTIA WEIGHT OF DRIVEN AXLE
C     AFTER TEST WEIGHT,INERTIA EQUIVALENCE OF DRIVE LINE
C     AND TOTAL INERTIA EQUIVALENCE OF ROTATING COMPONENTS
      READ(8,20,END=82)TRSIZE,TCODE,PRES,DWT,TSTWT,MR,TOTR,DYNO
C     GET TEST DATE, DRY BULB TEMPERATURE AND BAROMETER
      READ(8,30,END=83)IDATE,TIME,TDRY,BAR
C
      READ(8,7),END=84)NPAIR
      NRUNS=NPAIR*2
C
C
C
C     GET WIND INFO. FIRST MAGNITUDE, THEN DIRECTION.
C     1 MAGNITUDE NUMBER FOR THE HIGH SPEED PORTION
C     OF THE RUN AND ONE FOR THE LOW SPEED PORTION.
C     SAME FOR DIRECTION.
      NRUNS2=NRUNS*2
      READ(8,50,END=85)(WIND(J),J=1,NRUNS2)
      READ(8,60,END=86)(WDIR(J),J=1,NRUNS2)
C     GET POINT TOTALS FOR HIGH AND LOW SPEED PORTION OF THE RUNS
      READ(8,70,END=87)((IHIGH(J),ILOW(J)),J=1,NRUNS)
C
C...THE FOLLOWING READS A COMMENT CARD.ITIS READ BUT NOT PRINTED
C
      READ(8,1,END=88)CFRM
    1 FORMAT(20A4)
C
C
C     MR IS MASS EQUIV OF DRIVING WHEELS,TIRES AND DRIVETRAIN
C     MF IS MASS EQUIV OF NON-DRIVING WHEELS,TIRES AND BRAKE ASSEMBLY
      ACTUAL=.TRUE.
C     IF MR <= 0 OR TOTR<=0. USE FORMULA TO GET MR AND MF
      IF((MR .GT. 0.0) .AND.(TOTR .GT. 0.)) GO TO 30
C     SET FLAG TO INDICATE WE ARE USING FORMULA INERTIAS
      ACTUAL= .FALSE.
      MR=   .0180*TSTWT
C     MF = .0170*TSTWT
      TOTR= .0350*TSTWT
   30 CONTINUE
      MF= TOTR-MR
C
C     C1 IS A FACTOR TO CONVERT FROM ACCELERATION TO FORCE UNIT
C
      C1=(TSTWT+MR+MF)*88./(60.*G)
C
C     RK3 IS THE DENSITY RATIO  RHO(STANDARD)/RHO(TEST)
      RK3= ((RNK+TDRY)/(RNK+TSTD))*(STBAR/BAR)
C     RHOSTD IS THE AIR DENSITY AT STANDARD TEMPERATURE
      RHOSTD=.002378*(460.+75)/(460.+TSTD)
      RHO=RHOSTD/RK3
C
      WRITE(6,90)
      WRITE(6,100)TESTRN
      WRITE(6,110)MAIRUL ,MAKE ,MSTYL
      WRITE(6,120)TDATE ,TIME
      WRITE(6,130)PRES
      WRITE(6,135)TNSIZE,TCOND
      WRITE (6,140)
      WRITE (6,150)IDRY
      WRITE (6,160)BAR
      WRITE(6,170)ISTWT
      WRITE(6,180)DWT
      WRITE(6,190)NPAIR
      WRITE(6,200)
C     CALL ROUTINE TO SET UP LEAST SQUARE REGRESSION DATA FILE
      CALL WRITE(NRUNS,IHIGH,ILOW)
C     NOW DO LEAST SQUARES FIT
      CALL LSAD
C     REWIND THE FILE CONTAINING THE REGRESSION COEFFICIENTS
      REWIND 16
      DO 210 J=1,NRUNS
      READ(16,220,END=89)(A(J,I),I=1,3),RMS(J)
      WRITE(6,230)(A(J,I),I=1,3,2),RMS(J)
      GO TO 210
   81 WRITE(10,2)
      GO TO 195
   82 WRITE(10,3)
      GO TO 195
   83 WRITE(10,4)
      GO TO 195
   84 WRITE(10,5)
      GO TO 195
   85 WRITE(10,6)
      GO TO 195
   86 WRITE(10,7)
      GO TO 195
   87 WRITE(10,8)
      GO TO 195
   88 WRITE(10,9)
      GO TO 195
   89 WRITE(10,11)
  195 STOP
  210 CONTINUE
    2 FORMAT('0','*** END OF FILE REACHED ON UNIT 3 (BC21W-MVMA) WHEN
     $                TRYING TO READ THE FIRST LINE OF THE INPUT.',/)
    3 FORMAT('0','*** END OF FILE REACHED ON UNIT 3 (BC21W-MVMA) WHEN
     $                TRYING TO READ THE SECOND LINE OF THE INPUT.',/)
    4 FORMAT('0','*** END OF FILE REACHED ON UNIT 3 (BC21W-MVMA) WHEN
     $                TRYING TO READ THE THIRD LINE OF THE INPUT.',/)
    5 FORMAT('0','*** END OF FILE REACHED ON UNIT 3 (BC21W-MVMA) WHEN
     $                TRYING TO READ THE NUMBER OF PAIRS OF TEST RUNS.',/)
    6 FORMAT('0','*** END OF FILE REACHED ON UNIT 3 (BC21W-MVMA) WHEN
     $                               TRYING TO READ THE WIND SPEED.',/)
    7 FORMAT('0','*** END OF FILE REACHED ON UNIT 3 (BC21W-MVMA) WHEN
     &                               TRYING TO READ THE WIND DIRECTION.',/)
    8 FORMAT('0','*** END OF FILE REACHED ON UNIT 3 (BC21W-MVMA) WHEN
     $                TRYING TO READ THE VARIABLES IHIGH AND ILOW.',/)
    9 FORMAT('0','*** END OF FILE REACHED ON UNIT 3 (BC21W-MVMA) WHEN
     $                               TRYING TO READ THE COMMENT LINE.',/)
   11 FORMAT('0','*** END OF FILE REACHED ON UNIT 16 (-?).',/)
 10     FORMAT(I6,4X,3(7A2,A1))
 20     FORMAT(7A2,A1,1X,I2,2(1X,2F3.0),5F6.0)
 30     FORMAT(3I2,1X,2I2,1X,F4.0,1X,F5.2)
   40 FORMAT(20F4.1)
   60 FORMAT(20F4.0)
   70 FORMAT(10I1)
   90 FORMAT('1',T30,'ROAD COAST DOWN TEST')
  100 FORMAT(T14,'TEST RUN NO:',I6)
  110 FORMAT(T13,'VEHICLE:  ',3(7A2,A1))
  120 FORMAT(T11,'TEST DATE:',2X,2(I2,':'),I2,'  AT TIME ',2(I2,':'))
 130    FORMAT(T7,'RECOM PRES(F):',F3.0,'  R:',F3.0,' % TEST PRES(F):',
     4F3.0,' & R:',F3.0)
  135 FORMAT(T4,'TIRE & RIM SIZE: ',8A2,' TIRE CODE: ',I2)
  140 FORMAT(/T5,'TEST CONDITIONS',/T5,'---------------'/)
  150 FORMAT(T5,'AMBIENT TEMP.-F:  ',F5.0)
  160 FORMAT(T4,'BAROMETER IN HG.:',2X,F5.2)
  170 FORMAT(T4,'WT. (AFTER TEST):',2X,F5.0,2X,'(TOTAL)')
  180 FORMAT(T2,'DRIVEN AXLE WEIGHT:',2X,F5.0)
  190 FORMAT(/T5,'NO OF RUN PAIRS:',I3)
  200 FORMAT(//T15,' COEFFICIENTS IN TERMS OF A0,A2 (OBSERVED)',//,T14,
     &'A0',T40,'A2',T57,'RMS ERROR')
  220 FORMAT(1X,3(E17.8,1X),1X,E12.4)
  240 FORMAT(1X,E17.8,18X,E17.8,1X,E12.4,8X,I5,4X,2(2X,F6.2))
      RETURN
      END
      SUBROUTINE MINIZ(X,A,P,NC,P0,P1)
      DIMENSION A(3,3),X(2,150),P(3),FP(3),D(3),
     $P0(3),P1(3),PP0(3),COEF(3)
C     IW1 IS THE FILE CODE FOR THE DETAIL OF THE LEAST SQUARES FIT
C     IW2 IS THE FILE CODE FOR THE REGRESSION COEFFICIENTS
      DATA IW1/9/,IW2/16/
      NV=2
      NP1=3
      ND=2
      EPS=0.0001
      MXIT=100
      VSUM=0.
      DO 400 K=1,NC
  400 VSUM=VSUM+X(2,K)**2
      VBAR=VSUM/NC
      C=1.0
      NP=NP1-1
      MNAIL = 10
      NAIL = 0
      DO 557 I=1,NP
  557 PP0(I)=P(I)
C
      EPS1=5.00*EPS+1.00
      WRITE(IW1,195)
  195 FORMAT (33H0ITERATION    ERROR    PARAMETERS,/2X16HNO.  SUM    MEA
     $N,/14X,6HSQUARE,/)
   20 FORMAT(7H0MAX14A,15X,1P9E12.4/(22X,1P9E12.4))
  154 LLL=5
      LIT=1
      ND=NC
      R=0.
      LLLL=5
      CR = 7.2E-25
      DO 556 I=1,NP
  556 P(I)=PP0(I)
      FNC=NC-NP
   20 DO 85 I=1,NP1
      DO 85 J=1,I
   85 A(I,J)=0.
      DO 21 I=1,NC
      CALL FUN2(Q,FF,P,X(1,L))
      FP(NP1)=X(ND,L)-Q
      DO 1 I=1,NP1
      FPIC=FP(I)*C
      DO 1 J=1,I
    1 A(I,J)=A(I,J)+FPIC*FP(J)
    2 CONTINUE
      EE=A(NP1,NP1)/ENC
    6 IF(EE.LE.E0) GO TO 371
      NAIL=NAIL+1
      IF(NAIL.GT.MNAIL) GO TO 371
      DO 872 I=1,NP
      P(I)=PP0(I)+D(I)/2.D0
  872 D(I)=D(I)/2.D0
      GO TO 29
C
  371 WRITE(IW1,198)LIT,NAIL,EE,(P(I),I=1,NP)
  198 FORMAT(I6,1X,I2,1X,1P10E12.4/(22X,1P9E12.4))
      NAIL=0
 3191 LIT=LIT+1
      CALL STEP(A,D,P,PC,P1,NP1)
      IF(LIT.GT.MXIT) GO TO 200
      IF(EE.EQ.0.) GO TO 470
      PC=ABS((E0-EE)/EE)
      E0=EE
      IF(PC.LT.EPS) GO TO 100
      LLL=LLLL
  121 DO 28 I=1,NP
      PP0(I)=P(I)
   28 P(I)=P(I)+D(I)
      GO TO 29
  200 WRITE (IW1,201)
  201 FORMAT(30HOSTEP PROCESS IS NOT CONVERGING)
      GO TO 470
  100 LLL=LLL-1
      IF(LLL.NE.0) GO TO 121
  470 COEF(1)= P(1)
      COEF(2)= 0.0
      COEF(3)= P(1)*P(2)**2
      WRITE(IW1,789)
  789 FORMAT(9X,'A0',17X,'A1',17X,'A2',8X,'RMS ERROR (MPH)')
      SQRTEE=SQRT(EE)
      WRITE(IW1,790)COEF,SQRTEE
      WRITE(IW2,790)COEF,SQRTEE
  790 FORMAT(1X,3(E17.8,1X),1X,E12.4)
C     THE FOLLOWING DO LOOP PRINTS OUT THE EXPERIMENTAL AND PREDICTED
C     FUNCTION VALUES
      WRITE(IW1,553)
  553 FORMAT(58H1CASE          F                Y-F  STANDARD             VARIABL
     &ES,/30X,9HDEVIATION,/30X,11HOF ESTIMATE)
      DO 551 L=1,NC
      SDEST=0.0
      CALL FUN2(Q,FP,P,X(1,L))
      DO 24 I=1,NP
      DO 24 J=1,NP
   24 SDEST=SDEST+FP(I)*FP(J)*A(I,J)
      SDEST=SQRT(SDEST*EE)
      TT=X(ND,L)-Q
  551 WRITE(IW1,552)L,Q,TT,SDEST,(X(I,L),I=1,NV)
  552 FORMAT(1X,I4,10F12.5/(41X,7F12.5))
      RETURN
      END
      SUBROUTINE REJ2(XSD,XAV,ICHECK,OK)
C
C     ROUTINE TO DO STANDARD DEVIATION REJECTION
      COMMON /AREA1/ A(20,3),RMS(20),B(10,3),
     &WIDC(40),WDIR(40),S(10),NPAIR,NRUNS,NF
      COMMON /AREA2/MR,MF,ACTUAL,DYNO,TSTWT,C1,RK3,TDRY,TEFA
      DIMENSION XSD(3),XAV(3)
      DIMENSION VMIN(3),VMAX(3),TOT(3),AV(3)
      LOGICAL OK
C
C     IF EITHER THE A0 OR A2 PAIRED STANDARD DEVIATIONS ARE OUT
C     OF RANGE THE TEST FAILS AND WE REJECT THE PAIR WHICH IS
C     FARTHEST FROM THE MEAN.
C
      TOL1= AMAX1(2.5),.05*XAV(1))
      TOL3= AMAX1(.001,.03*XAV(3))
      IF((XSD(1) .LE. TOL1) .AND.(XSD(3) .LE. TOL3))GO TO 40
      IFACT1=0
      IFACT2=0
      IF(XSD(1) .GT. TOL1) IFACT1=1
      IF(XSD(3) .GT. TOL3) IFACT2=1
      DIFOLD=0.
      DIFF=0.
      ILOC=1
      DO 10 J=1,NPAIR
      IF(S(J) .LE. 0.) GO TO 10
      R1=XAV(1)-C1*B(J,1)
      R2= (XAV(3)-C1*B(J,3))
      DIFF= IFACT1*ABS(R1)+IFACT2*ABS(R2)
      IF(DIFF .LE. DIFOLD) GO TO 10
      DIFOLD=DIFF
      ILOC=J
   10 CONTINUE
C     ILOC IS THE NUMBER OF THE PAIR WHICH IS FARTHEST FROM THE
C     MEAN. IT IS THE ONE TO BE REJECTED
      S(ILOC)=0.
      WRITE(6,20)ILOC
   20 FORMAT(/T10,'PAIR ',I6,2X,'REJECTED DUE TO STANDARD DEVIATION')
      ICHECK=ICHECK-1
      WRITE(6,30)ICHECK
   30 FORMAT(T10,'NUMBER OF PAIRS REMAINING IS',I8)
      IF(ICHECK .GE. 3) GO TO 60
      WRITE(6,50)
   50 FORMAT(T10,'NOT ENOUGH DATA TO PROCEED')
      STOP
   60 CALL TALLY(B,S,TOT,XAV,XSD,VMIN,VMAX,NPAIR,3,NF)
      WRITE(6,70)
   70 FORMAT(/T10,'RESULTS AFTER STANDARD DEVIATION  REJECTIONS')
C     CHANGE TO FORCE UNITS
      CALL UNIT(XSD)
      WRITE(6,80)XAV(1),XSD(1),XAV(3),XSD(3)
      CALL UNIT(XAV)
C     THIS RETURN IS USED IF A PAIR HAS BEEN REJECTED
      RETURN
   40 CONTINUE
      OK= .TRUE.
   80 FORMAT(/T10,'AVERAGE COEFFICENTS',T53,'STANDARD DEVIATIONS',//
     $T10,'A0 =',3X,E16.7,2X,'(MI/HR-SEC)',T50,E16.7,2X,'(LBS)',
     $//T10,'A2 =',3X,E16.7,2X,'(HR/MI-SEC)',T50,E16.7,2X,'(LBS)')
C     THIS RETURN IS USED IF THE STANDARD DEVIATION CRITERIA HAS BEEN MET
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```
      RETURN
      END
      SUBROUTINE REJECT(ICHECK)
C
C     THIS ROUTINE DOES RMS REJECTION
      COMMON /AREA1/ A(20,5),RMS(20),H(10,2),
     $WIND(40),ADIR(40),S(10),NPAIR,NRUNS,NF
C
C
      DATA TOL1/0.25/
C     IF RMS > TOL1
C     WE MUST REJECT THE RUN AND ITS PAIR
C
      DO 10 J=1,NRUNS,2
      K=(J+1)/2
      IF((RMS(J).LE.TOL1.AND.RMS(J+1).LE.TOL1))GO TO 20
      S(K)= 0.
      WRITE(6,30)K
   30 FORMAT(T10,'PAIR ',I4,' HAS BEEN REJECTED DUE TO HIGH RMS')
   20 CONTINUE
C
C     REJECT THE RUN
C     IF S(K)= 0. TALLY IGNORES THE DATA FOR THAT K
C
   10 CONTINUE
      ICHECK=0
      DO 40 JC=1,NPAIR
      ICHECK=ICHECK+S(JC)
   40 CONTINUE
C
      IF((ICHECK.EQ.NPAIR))GO TO 60
      NREJ=NPAIR-ICHECK
      WRITE(6,50) NREJ
   50 FORMAT(/T7,I4,' PAIR(S) OF RUNS HAVE BEEN REJECTED')
   60 CONTINUE
      IF((ICHECK.GE.3))GO TO 70
      WRITE(6,80)
   80 FORMAT(/T10,'NOT ENOUGH DATA TO PROCEED')
      STOP
   70 CONTINUE
      RETURN
      END
      SUBROUTINE SELECT(X,NC)
      REAL X(2,150)
      DATA VSTART/60.0/,VSTOP/20.0/
      KOUNT=NC
C
C     FIND THE FIRST DATA POINT <= VSTART
C
      DO 100 J=1,KOUNT
      ISTART=J
      IF( X(2,J).LE. VSTART)GO TO 200
  100 CONTINUE
C
C     FIND THE LAST DATA POINT <= VSTOP
C
  200 DO 300 J=ISTART,KOUNT
      ISTOP=J
      IF (X(2,J) .LE..VSTOP) GO TO 400
  300 CONTINUE
  400 NC=ISTOP-ISTART+1
```

```
C
C     COPY THE USEFUL DATA BACK INTO THE TIME-VELOCITY ARRAY
C
      DO 560 K=1,NC
      X(2,K)= X(2,ISTART+K-1)
  560 CONTINUE
      RETURN
      END
      SUBROUTINE SPLICE(VHIGH,VLOW,IHIGH,ILOW,VEL,IVEL)
C
C     THIS SUBROUTINE TAKES A HIGH VELOCITY VECTOR VHIGH
C     AND A LOW VELOCITY VECTOR VLOW AND SPLICES THEM
C     TO PRODUCE A NEW VECTOR VEL. VHIGH AND VLOW ARE
C     AVERAGED ACROSS THE OVERLAP
C
C     INPUT ARGUMENTS
C     VHIGH WHICH HAS LENGTH IHIGH
C     VLOW  WHICH HAS LENGTH ILOW
C
C     OUTPUT  VEL  WITH LENGTH IVEL
C
      DIMENSION VHIGH(150),VLOW(150),VEL(200)
C
C     FIND POINT IN VHIGH CLOSEST TO VLOW(1)
      I = 0
C     I WILL BECOME SUBSCRIPT OF THIS POINT IN VHIGH.
      DIFF = 1.0E+4
C
C     IF ILOW <1 WE HAVE ONLY ONE DATA SET
C
      IF(ILOW .LE. 0) GO TO 60
      DO 10 J=1,IHIGH
      DIFNEW = ABS(VLOW(1)-VHIGH(J))
      IF(DIFNEW .GE. DIFF) GO TO 20
      DIFF = DIFNEW
C     RESET FOR NEXT COMPARISON.
      I=J
   20 CONTINUE
   10 CONTINUE
C
C     VELOCITIES BEFORE THE MATCH ARE LOADED DIRECTLY
C     FROM VHIGH TO OUTPUT VECTOR VEL
C
      II=I-1
      DO 30 IFIRST=1,II
      VEL(IFIRST)=VHIGH(IFIRST)
   30 CONTINUE
C
C     NOW AVERAGE ACROSS OVERLAP
C
      L=0
      DO 40 JAV=I,IHIGH
      L=L+1
      VEL(JAV)=.5*(VHIGH(JAV)+VLOW(L))
   40 CONTINUE
C
C     L IS THE LENGTH OF THE OVERLAP
C
      K=0
C
C     NOW COPY THE REST OF VLOW TO VEL
```

```
C
      L1=L+1
      DO 50 ILAST=L1,ILOW
      K=K+1
      VEL(IHIGH+K)=VLOW(ILAST)
   50 CONTINUE
C
C     LENGTH OF VEL IS IHIGH+K
C
      IVEL=IHIGH+K
      GO TO 110
C
C
C     THIS IS THE CASE WHERE THE  LOW VELOCITY VECTOR IS EMPTY
C
   60 DO 100 IFIRST=1,IHIGH
      VEL(IFIRST)=VHIGH(IFIRST)
  100 CONTINUE
      IVEL =IHIGH
  110 CONTINUE
      RETURN
      END
      SUBROUTINE STEP(A,D,P,P0,P1,NP1)
      REAL A(3,3),V(3),D(3),IN(3),P0(3),P1(3),P(3)
C
      TOL=0.00001
      NP=NP1-1
      DO 20 I=1,NP1
      V(I)=SQRT(A(I,I))
      DO 20 J=1,I
      IF (V(I)*V(J).EQ.0.) GO TO 212
      A(I,J)=A(I,J)/(V(I)*V(J))
      GO TO 20
  212 A(I,J)=0.
   20 CONTINUE
      DO 2 I=1,NP
    2 IN(I)=0
    8 K=0
      R=0.
      DO 1 I=1,NP
      IF(IN(I).NE.0 .OR. A(I,I).LE.TOL) GO TO 1
      Q=A(NP1,I)*A(NP1,I)/A(I,I)
      IF(Q.LE.R) GO TO 1
      K=I
      R=Q
    1 CONTINUE
      IF(K.EQ.0) GO TO 3
      C=-1.
    4 DO 5 I=1,K
      D(I)=A(K,I)
    5 A(K,I)=0.
      PP=D(K)
      DO 6 I=K,NP1
      D(I)=A(I,K)
    6 A(I,K)=0.
      D(K)=C
      IN(K)=IN(K)+1
      DO 7 I=1,NP1
      IF (PP.LE.0..OR.D(I).EQ.0.) GO TO 24
      Y=D(I)/PP
      GO TO 25
```

```
     24 Y=0.
     25 CONTINUE
        DO 7 J=1,I
      7 A(I,J)=A(I,J)-B(J)*Y
        GO TO 8
      4 R=1.
        DO 9 I=1,NP
        IF(IN(I).NE.1) GO TO 9
        IF (V(I).EQ.0.) GO TO 15
        D(I)=A(NP1,I)*V(NP1)/V(I)
C
     16 IF (D(I).EQ.0.) GO TO 17
        H=AMAX1((P0(I)-P(I))/D(I),(P1(I)-P(I))/D(I))
        GO TO 18
     15 D(I)=0.0
     17 H=0.
     18 CONTINUE
        IF(H.GE.R) GO TO 9
        R=H
        K=I
      9 CONTINUE
        C=1.
        IF(R.LE.TOL) GO TO 4
        DO 10 I=1,NP
        IF(IN(I).NE.1) GO TO 11
        B(I)=D(I)*R
        DO 21 J=1,I
        IF ((V(I)*V(J)).EQ.0.0) GO TO 30
        A(I,J)=-A(I,J)/(V(I)*V(J))
        GO TO 21
     30 A(I,J)=0.
     21 A(J,I)=A(I,J)
        GO TO 10
     11 B(I)=0.
        DO 22 J=1,NP
        A(I,J)=0.
     22 A(J,I)=0.
     10 CONTINUE
        RETURN
        END
CTALLY                TALLY    04JAN71T
        SUBROUTINE TALLY(A,S,TOTAL,AVER,SD,VMIN,VMAX,NO,NV,NF)
        DIMENSION A(NR,NV),S(1),TOTAL(1),AVER(1),SD(1),VMIN(1),VMAX(1)
C
C      .................................................................
C
C          SUBROUTINE TALLY
C
C
C          PURPOSE
C             CALCULATE TOTAL,MEAN,STANDARD DEVIATION,MINIMUM, MAXIMUM
C             FOR EACH VARIABLE IN A SET (OR A SUBSET) OF OBSERVATIONS
C
C          USAGE
C             CALL TALLY(A,S,TOTAL,AVER,SD,VMIN,VMAX,NO,NV,NF)
C
C          DESCRIPTION OF PARAMETERS
C             A       - OBSERVATION MATRIX, NR BY NV
C             S       - INPUT VECTOR INDICATING SUBSET OF A. ONLY THOSE
C                       OBSERVATIONS WITH A NON-ZERO S(J) ARE CONSIDERED.
C                       VECTOR LENGTH IS NO.
```

```
C             NO       NUMBER OF OBSERVATIONS
C             NV       NUMBER OF VARIABLES
C             NO       NUMBER OF ROWS IN MATRIX A
C             TOTAL  - OUTPUT VECTOR OF TOTALS OF EACH VARIABLE. VECTOR
C                      LENGTH IS NV.
C             AVER   - OUTPUT VECTOR OF AVERAGES OF EACH VARIABLE. VECTOR
C                      LENGTH IS NV
C             SD     - OUTPUT VECTOR OF STANDARD DEVIATIONS OF EACH
C                      VARIABLE.VECTOR LENGTH IS NV.
C             VMIN   - OUTPUT VECTOR OF MINIMA OF EACH VARIABLE. VECTOR
C                      LENGTH IS NV.
C             VMAX   - OUTPUT VECTOR OF MAXIMA OF EACH VARIABLE. VECTOR
C                      LENGTH IS NV.
C             NO     - NUMBER OF OBSERVATIONS
C             NV     - NUMBER OF VARIABLES FOR EACH OBSERVATION
C
C          REMARKS
C             NONE
C
C
C          METHOD
C             ALL OBSERVATIONS CORRESPONDING TO A NON-ZERO ELEMENT IN S
C             VECTOR ARE ANALYZED FOR EACH VARIABLE IN MATRIX A.
C             TOTALS ARE ACCUMULATED AND MINIMUM AND MAXIMUM VALUES ARE
C             FOUND. FOLLOWING THIS, MEANS AND STANDARD DEVIATIONS ARE
C             CALCULATED.  THE DIVISOR FOR STANDARD DEVIATION IS ONE LESS
C             THAN THE NUMBER OF OBSERVATIONS USED.
C
C       ..................................................................
C
C
C          CLEAR OUTPUT VECTORS AND INITIALIZE VMIN,VMAX
C
      DO 1 K=1,NV
      TOTAL(K)=0.0
      AVER(K)=0.0
      SD(K)=0.0
      VMAX(K)=-1.0E 38
    1 VMIN(K)=1.0E 38
C
C          TEST SUBSET VECTOR
C
      SCNT=0.0
      DO 7 J=1,NO
      IF(S(J)) 2,7,2
    2 SCNT=SCNT+1.0
C
C          CALCULATE TOTAL, MINIMA, MAXIMA
C
      DO 6 I=1,NV
      TOTAL(I)=TOTAL(I)+A(J,I)
      IF(A(J,I)-VMIN(I)) 3,4,4
    3 VMIN(I)=A(J,I)
    4 IF(A(J,I)-VMAX(I)) 6,6,5
    5 VMAX(I)=A(J,I)
    6 SD(I)=SD(I)+A(J,I)*A(J,I)
    7 CONTINUE
C
C          CALCULATE MEANS AND STANDARD DEVIATIONS
C
      DO 8 I=1,NV
      AVER(I)=TOTAL(I)/SCNT
    1 SD(I)=SQRT(ABS((SD(I)-TOTAL(I)*TOTAL(I)/SCNT)/(SCNT-1.0)))
      RETURN
      END
      SUBROUTINE TIME(AV,DELT)
C     COMPUTE THE CLAST TIME FROM V1 TO V2
C     AV(1)=A0 ,AV(2)= A1, AV(3)= A2
      DIMENSION AV(3)
      V1=55.
      V2=45.
      S=SQRT(4.*AV(1)*AV(3)-AV(2)**2)
      ARG1=(2.*AV(3)*V1 +AV(2))/S
      ARG2=(2.*AV(3)*V2+AV(2))/S
      T1=-ATAN(ARG1)/(.5*S)
      T2=-ATAN(ARG2)/(.5*S)
      DELT=T2-T1
      RETURN
      END
      SUBROUTINE UNIT(R)
C
C     THIS SUBROUTINE MULTIPLIES BY C1 TO
C     CHANGE UNITS TO LBS
C
C     ARGUMENTS R
C
      COMMON /AREAP/MR,MF,ACTUAL,DYNO,TSTAT,C1,PK3,TDRY,TEPS
      DIMENSION R(3)
C
      DO 100 K=1,3
      R(K)=R(K)*C1
  100 CONTINUE
      RETURN
      END
      SUBROUTINE WRITE(NRUNS,IHIGH,ILOW)
C
      DIMENSION VHIGH(150),VLOW(150),VEL(200)
      DIMENSION IHIGH(20),ILOW(20)
C
C     DATA IWH/15/,IWL/14/
C     IWH IS THE FILE CODE FOR THE HI SPEED PORTION OF THE RUN
C     IWL IS THE FILE CODE FOR THE LOW SPEED PORTION OF THE RUN
C
C
C
      DO 20 J=1,NRUNS
      IHJ=IHIGH(J)
      READ(1,3),END=5)(VHIGH(M),M=1,IHJ)
C     ILOW <= 0 MEANS WE HAVE A NON SPLIT RUN
      IF(ILOW(J) .LE. 0) GO TO 41
      ILJ=ILOW(J)
      READ(4,3),END=10)(VLOW(M),M=1,ILJ)
   41 CONTINUE
    3 FORMAT(12F6.2)
      CALL SPLICE(VHIGH,VLOW,IHIGH(J),ILOW(J),VEL,IVEL)
C     WRITE OUT FORMATTED DATA OUT
      NIVEL = IVEL
      DO 55 K = 1,IVEL
      IF(VEL(K) .EQ. 0.0) NIVEL = NIVEL-1
   55 CONTINUE
      WRITE(6,60)J,NIVEL
   60 FORMAT(T2,I2,T24,I3)
```

```
      DO 70 K=1,IVEL
      CNT=(K-1)
      IF(VEL(K) .EQ. 0.0) GO TO 70
      WRITE(05,80)CNT,VEL(K)
   80 FORMAT(2X,F8.2,2X,F5.2)
   70 CONTINUE
   20 CONTINUE
      WRITE(05,90)
   90 FORMAT(' END')
      REWIND 05
      GO TO 100
    5 WRITE(10,6)
    6 FORMAT('0','*** END OF FILE REACHED ON UNIT 3 (8021W-MVMA) WHEN
     &   TRYING TO READ THE SPEED POINTS INTO THE ARRAY VHIGH .',/)
      GO TO 95
   10 WRITE(10,11)
   11 FORMAT('0','*** END OF FILE REACHED ON UNIT 3 (8021W-MVMA) WHEN
     &   TRYING TO READ THE SPEED POINTS INTO THE ARRAY VLOW.',/)
   95 STOP
  100 RETURN
      END
      SUBROUTINE XWIND
C
      DATA PI/3.1415927/
      COMMON /AREA1/ A(20,3),RMS(20),B(10,3),
     &WIND(40),WDIR(40),S(10),NPAIR,NRUNS,NF
C
C     CONVERT ANGLE TO RADIAN MEASURE
C
      NRUNS2=NRUNS*2
      DO 100 I=2,NRUNS2,2
      WDIR(I)= (WDIR(I))*PI/180.
      WDIR(I-1)= (WDIR(I-1))*PI/180.
C     AVERAGE PARALLEL COMPONENTS FROM HIGH AND LOW SPEED PORTIONS OF A
C     IF THE RUN IS NOT A SPLIT RUN THIS ROUTINE CAN STILL BE USED IF
C     THE SAME WIND DATA IS PUT IN TWICE FOR EACH RUN. I.E. ONCE FOR
C     THE HIGH SPEED PORTION AND ONCE FOR THE "LOW SPEED PORTION" EVEN
C     THOUGH IT IS EMPTY
      W=.5*(WIND(I-1)*COS(WDIR(I-1))+WIND(I)*COS(WDIR(I)))
C
C     CORRECT FOR ONLY THE PARALLEL COMPONENT OF WIND
      J=I/2
C     J IS THE RUN NUMBER
      A(J,1)= A(J,1) -A(J,3)*W**2
  100 CONTINUE
      RETURN
      END
```

APPENDIX 6
TO ANNEX C

COAST EXECUTE

```
1.      //COAST JOB (E7025,[illegible],C,2,10),'[illegible]',
1.01    //   [illegible]K
3.      //STEP   EXEC PROC=FTG1CLG
4.      //FORT.SYSIN DD DSN=C91.E7025C.COAST.SOURCE,VOL=SER=WYL101,
5.      // UNIT=3330-1,DISP=(OLD,KEEP),
6.      // DCB=(RECFM=FB,LRECL=80,BLKSIZE=3120)
7.      //GO.FT05F001 DD DSN=[illegible],DISP=(NEW,KEEP,KEEP),UNIT=2400,
8.      // DCB=(RECFM=FB,LRECL=80,BLKSIZE=3120)
8.1     //GO.FT06F001 DD SYSOUT=A
9.      //GO.FT08F001 DD DSN=C91.E7025C.COAST.OUT,DISP=(OLD,KEEP,KEEP),
10.     //*VOL=SER=WYL001,UNIT=3330-1,SPACE=(TRK,(2,2),RLSE),
11.     //*DCB=(RECFM=FB,LRECL=121,BLKSIZE=3025)
12.     //GO.FT09F001 DD DSN=C91.E7025C.COAST.DAT3500,DISP=SHR,
13.     // VOL=SER=WYL001,UNIT=3330-1,DCB=(RECFM=FB,LRECL=80,BLKSIZE=3120)
14.     //GO.FT10F001 DD DSN=FILE[illegible],DISP=(NEW,KEEP,KEEP),UNIT=2400,
15.     // DCB=(RECFM=FB,LRECL=80,BLKSIZE=3120)
16.     //GO.FT11F001 DD DSN=C91.E7025C.COAST.ERR.MESSG,DISP=(OLD,KEEP),
17.     // VOL=SER=WYL001,UNIT=3330-1,DCB=(RECFM=FB,LRECL=121,BLKSIZE=3025),
18.     // SPACE=(TRK,(2,2),RLSE)
19.     //GO.FT16F001 DD DSN=REGRESS,DISP=(NEW,KEEP,KEEP),UNIT=2400,
20.     // DCB=(RECFM=FB,LRECL=80,BLKSIZE=3120)
21.     //GO.SYSUDUMP DD SYSOUT=A
22.     //
```

APPENDIX 7
TO ANNEX C

COAST WRITE

```
//STEP1    EXEC PGM=IEBGENER
//SYSPRINT DD SYSOUT=A
//SYSIN DD DUMMY
//SYSUT2 DD SYSOUT=A,DCB=(RECFM=F,LRECL=80),BLKSIZE=80)
//SYSUT1 DD DSN=[illegible],UNIT=2400,DCB=(LRECL=80,RECFM=FB,BLKSIZE=3120),
//STEP2    EXEC PGM=IEBGENER
//SYSPRINT DD SYSOUT=A
//SYSIN DD DUMMY
//SYSUT2 DD SYSOUT=A,DCB=(RECFM=F,LRECL=80,BLKSIZE=80)
//SYSUT1 DD DSN=FILE[illegible],UNIT=2400,DCB=(LRECL=80),RECFM=FB,BLKSIZE=3120),
//STEP3    EXEC PGM=IEBGENER
//SYSPRINT DD SYSOUT=A
//SYSIN DD DUMMY
//SYSUT2 DD SYSOUT=A,DCB=(RECFM=F,LRECL=80),BLKSIZE=80)
//SYSUT1 DD DSN=[illegible]S,UNIT=2400,DCB=(LRECL=80,RECFM=FB,BLKSIZE=3120).
//
```

APPENDIX 8
TO ANNEX C

SPEED, FILE 09

REGRESSION

SPEED

```
1                               25
      0.0      55.34
      3.00     52.19
      6.00     49.42
      9.00     46.87
     12.00     44.68
     15.00     42.84
     18.00     40.90
     21.00     38.87
     24.00     36.82
     27.00     35.24
     30.00     33.35
     33.00     31.66
     36.00     30.32
     39.00     29.12
     42.00     27.64
     45.00     26.14
     48.00     24.66
     51.00     23.51
     54.00     22.58
     57.00     21.46
     60.00     20.46
     63.00     19.17
     66.00     18.34
     69.00     17.12
     72.00     16.01
2                               25
      0.0      57.47
      3.00     54.13
      6.00     51.04
      9.00     48.49
     12.00     46.02
     15.00     43.59
     18.00     41.45
     21.00     39.38
     24.00     37.44
     27.00     35.74
     30.00     33.95
     33.00     32.16
     36.00     30.87
     39.00     29.67
     42.00     28.16
     45.00     26.70
     48.00     25.33
     51.00     23.77
     54.00     22.53
     57.00     21.66
     60.00     20.52
     63.00     19.35
     66.00     18.53
     69.00     17.12
     72.00     16.31
3                               24
      0.0      51.99
      3.00     49.31
      6.00     46.88
      9.00     44.57
     12.00     42.53
     15.00     40.38
     18.00     38.11
     21.00     36.10
     24.00   34.24
     27.00   32.55
     30.00   31.27
     33.00   29.64
     36.00   28.28
     39.00   27.25
     42.00   25.56
     45.00   24.47
     48.00   23.10
     51.00   21.84
     54.00   20.81
     57.00   19.64
     60.00   18.50
     63.00   17.52
     66.00   16.33
     69.00   15.27
4                         23
      0.0    56.23
      3.00   53.43
      6.00   49.73
      9.00   46.94
     12.00   44.49
     15.00   42.23
     18.00   39.95
     21.00   38.05
     24.00   36.00
     27.00   34.03
     30.00   32.53
     33.00   30.77
     36.00   29.22
     39.00   27.71
     42.00   26.28
     45.00   24.86
     48.00   23.52
     51.00   22.08
     54.00   20.88
     57.00   20.18
     60.00   18.80
     63.00   17.73
     66.00   16.81
5                         26
      0.0    57.67
      3.00   54.27
      6.00   51.46
      9.00   48.72
     12.00   46.13
     15.00   44.25
     18.00   42.15
     21.00   40.24
     24.00   38.55
     27.00   36.32
     30.00   34.54
     33.00   33.01
     36.00   31.68
     39.00   29.63
     42.00   28.45
     45.00   27.04
     48.00   25.24
     51.00   24.38
     54.00   22.86
     57.00   22.04
     60.00    20.95
     63.00    19.76
     66.00    18.47
     69.00    17.50
     72.00    16.33
     75.00    15.24
6                           24
      0.0     54.70
      3.00    52.13
      6.00    49.12
      9.00    46.22
     12.00    43.62
     15.00    41.66
     18.00    39.59
     21.00    37.73
     24.00    35.73
     27.00    34.29
     30.00    32.27
     33.00    30.85
     36.00    29.54
     39.00    28.22
     42.00    26.45
     45.00    25.[illegible]
     48.00    [illegible]
     51.00    22.71
     54.00    21.99
     57.00    20.97
     60.00    19.55
     63.00    18.39
     66.00    17.49
     69.00    16.65
7                           24
      0.0     57.34
      3.00    54.25
      6.00    51.65
      9.00    48.81
     12.00    46.29
     15.00    43.90
     18.00    42.12
     21.00    40.00
     24.00    37.99
     27.00    36.16
     30.00    34.25
     33.00    32.52
     36.00    30.78
     39.00    29.45
     42.00    27.85
     45.00    26.62
     48.00    25.28
     51.00    23.81
     54.00    22.61
     57.00    21.99
     60.00    20.76
     63.00    19.79
     66.00    18.20
     69.00    17.68
8                           24
      0.0     57.13
      3.00    54.18
      6.00    51.25
      9.00    48.51
     12.00    45.79
     15.00    43.51
     18.00    41.21
     21.00    39.43
     24.00    37.21
     27.00    35.25
     30.00    33.51
     33.00    31.75
     36.00    30.14
     39.00    28.59
     42.00    27.51
     45.00    25.80
     48.00    24.42
     51.00    23.46
     54.00    22.09
     57.00    20.90
     60.00    19.79
     63.00    18.19
     66.00    17.41
     69.00    16.33
9                              25
      0.0     58.22
      3.00    55.52
      6.00    52.33
      9.00    49.70
     12.00    46.95
     15.00    44.85
     18.00    42.61
     21.00    40.70
     24.00    38.29
     27.00    36.14
     30.00    34.18
     33.00    32.85
     36.00    30.91
     39.00    29.65
     42.00    28.29
     45.00    26.47
     48.00    25.84
     51.00    24.19
     54.00    23.29
     57.00    22.06
     60.00    20.89
     63.00    19.87
     66.00    18.27
     69.00    17.59
     72.00    16.74
                               25
      0.0     59.61
      3.00    56.08
      6.00    53.10
      9.00    49.94
     12.00    47.25
     15.00    44.63
     18.00    42.48
     21.00    40.33
     24.00    38.02
     27.00    36.03
     30.00    34.31
     33.00    32.56
     36.00    31.21
     39.00    29.38
```

```
    42.00   28.01
    45.00   26.57
    48.00   25.41
    51.00   23.96
    54.00   22.35
    57.00   21.61
    60.00   20.07
    63.00   19.04
    66.00   17.75
    69.00   16.85
    72.00   15.94
ND
```

```
0ITERATION      ERROR       PARAMETERS
  NO.   SHF     MEAN
                SQUARE

      0  0    2.4841E+00   2.9190E-01   2.5500E-02
      1  0    8.3002E-02   2.5834E-01   3.0670E-02
      2  0    3.7266E-02   2.6337E-01   3.0494E-02
      3  0    3.7259E-02   2.6338E-01   3.0497E-02
      4  4    3.7259E-02   2.6338E-01   3.0497E-02
      5 11    3.7259E-02   2.6338E-01   3.0497E-02
      6 11    3.7260E-02   2.6338E-01   3.0497E-02
      7  4    3.7259E-02   2.6338E-01   3.0497E-02
      8 11    3.7260E-02   2.6338E-01   3.0497E-02
           A0                           A1                    A2               RMS ERROR (MPH)
 0.26337594E+00         0.0                             0.24495507E-03          0.1930E+00
CASE          F                Y-F    STANDARD                   VARIABLES
                                      DEVIATION
                                      OF ESTIMATE
    1       55.33984       0.00015      0.00000        0.0          55.34000
    2       52.41747      -0.22746      0.02083        3.00000      52.19000
    3       49.71194      -0.29195      0.03627        6.00000      49.42000
    4       47.19714      -0.32715      0.04734        9.00000      46.87000
    5       44.85095      -0.17096      0.05484       12.00000      44.67999
    6       42.65453       0.18547      0.05945       15.00000      42.84000
    7       40.59166       0.30833      0.06170       18.00000      40.89999
    8       38.64830       0.22169      0.06208       21.00000      38.87000
    9       36.81229       0.00772      0.06101       24.00000      36.82001
   10       35.07304       0.16696      0.05890       27.00000      35.24001
   11       33.42120      -0.07120      0.05616       30.00000      33.35001
   12       31.84857      -0.18857      0.05323       33.00000      31.66000
   13       30.34787      -0.02786      0.05062       36.00000      30.32001
   14       28.91267       0.20732      0.04890       39.00000      29.12000
   15       27.53720       0.10280      0.04864       42.00000      27.64000
   16       26.21629      -0.07629      0.05026       45.00000      26.14000
   17       24.94534      -0.28534      0.05396       48.00000      24.66000
   18       23.72015      -0.21016      0.05962       51.00000      23.50999
   19       22.53694       0.04306      0.06698       54.00000      22.58000
   20       21.39230       0.06770      0.07574       57.00000      21.46001
   21       20.28310       0.17691      0.08561       60.00000      20.46001
   22       19.20648      -0.03648      0.09639       63.00000      19.17000
ITERATION      ERROR       PARAMETERS
  NO.   SHF    MEAN
               SQUARE

    0  0    5.0261E+00   2.9190E-01   2.5500E-02
    1  0    2.1174E-01   2.4636E-01   3.2359E-02
    2  0    2.5989E-02   2.5564E-01   3.2036E-02
    3  0    2.5917E-02   2.5566E-01   3.2046E-02
    4  0    2.5915E-02   2.5566E-01   3.2047E-02
    5 11    2.5916E-02   2.5566E-01   3.2047E-02
    6  3    2.5916E-02   2.5566E-01   3.2047E-02
    7 11    2.5916E-02   2.5566E-01   3.2047E-02
    8  0    2.5915E-02   2.5566E-01   3.2047E-02
         A0                            A1                    A2               RMS ERROR (MPH)
 0.25566071E+00         0.0                             0.26255939E-03          0.1610E+00
ASE           F                Y-F    STANDARD                   VARIABLES
                                      DEVIATION
                                      OF ESTIMATE
    1       57.46980       0.00020      0.00000        0.0          57.47000
    2       54.24646      -0.11646      0.01802        3.00000      54.13000
    3       51.28743      -0.24744      0.03116        6.00000      51.03999
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     4     48.55833     -0.06833      0.04040      9.00000     48.49001
     5     46.03024     -0.01024      0.04653     12.00000     46.02000
     6     43.67914     -0.08914      0.05016     15.00000     43.59000
     7     41.48441     -0.03441      0.05180     18.00000     41.45000
     8     39.42863     -0.04863      0.05189     21.00000     39.38000
     9     37.49673     -0.05673      0.05080     24.00000     37.44000
    10     35.67565      0.06432      0.04888     27.00000     35.74001
    11     33.95419     -0.00420      0.04648     30.00000     33.95000
    12     32.32242     -0.16241      0.04400     33.00000     32.16000
    13     30.77171      0.09828      0.04186     36.00000     30.87000
    14     29.29439      0.37561      0.04051     39.00000     29.67000
    15     27.88373      0.27628      0.04041     42.00000     28.16000
    16     26.53369      0.16631      0.04189     45.00000     26.70000
    17     25.23897      0.09103      0.04505     48.00000     25.33000
    18     23.99471     -0.22470      0.04978     51.00000     23.77000
    19     22.79663     -0.26663      0.05584     54.00000     22.53000
    20     21.64082      0.01918      0.06300     57.00000     21.66000
    21     20.52376     -0.00375      0.07103     60.00000     20.52000
    22     19.44226     -0.09225      0.07976     63.00000     19.35001
0ITERATION      ERROR      PARAMETERS
  NO.   SHF     MEAN
                SQUARE

     0  0    2.8327E+00   2.9190E-01   2.5500E-02
     1  0    5.2306E-02   2.6647E-01   3.0556E-02
     2  0    3.6144E-02   2.7336E-01   3.0071E-02
     3  0    3.6122E-02   2.7332E-01   3.0083E-02
     4  1    3.6120E-02   2.7332E-01   3.0083E-02
     5  5    3.6119E-02   2.7332E-01   3.0083E-02
     6 11    3.6120E-02   2.7332E-01   3.0083E-02
     7  5    3.6120E-02   2.7332E-01   3.0083E-02
     8  5    3.6120E-02   2.7332E-01   3.0083E-02
          A0                  A1                    A2              RMS ERROR (MPH)
  0.27332145E+00        0.0                   0.24735089E-03       0.1901E+00
1CASE        F               Y-F    STANDARD             VARIABLES
                                    DEVIATION
                                    OF ESTIMATE
     1     51.98994      0.00006      0.00000      0.0         51.99001
     2     49.26869      0.04131      0.02230      3.00000     49.31000
     3     46.73941      0.14059      0.03867      6.00000     46.88000
     4     44.37975      0.19026      0.05020      9.00000     44.57001
     5     42.17056      0.35944      0.05777     12.00000     42.53000
     6     40.09547      0.28453      0.06211     15.00000     40.38000
     7     38.14030     -0.03030      0.06384     18.00000     38.11000
     8     36.29282     -0.19281      0.06352     21.00000     36.10001
     9     34.54222     -0.30222      0.06168     24.00000     34.24001
    10     32.87918     -0.32918      0.05885     27.00000     32.55000
    11     31.29535     -0.02534      0.05561     30.00000     31.27000
    12     29.78343     -0.14343      0.05265     33.00000     29.64000
    13     28.33690     -0.05690      0.05079     36.00000     28.28000
    14     26.94997      0.30003      0.05083     39.00000     27.25000
    15     25.61742     -0.05742      0.05339     42.00000     25.56000
    16     24.33461      0.13539      0.05863     45.00000     24.47000
    17     23.09732      0.00269      0.06633     48.00000     23.10001
    18     21.90172     -0.06172      0.07606     51.00000     21.84000
    19     20.74438      0.06561      0.08741     54.00000     20.81000
    20     19.62213      0.01787      0.10005     57.00000     19.64000
0ITERATION      ERROR      PARAMETERS
  NO.   SHF     MEAN
                SQUARE
    0  0    9.6816E+00   2.9190E-01   2.5500E-02
    1  0    1.3472E-01   2.5928E-01   3.2740E-02
    2  0    3.0808E-02   2.7585E-01   3.1531E-02
    3  0    2.9750E-02   2.7573E-01   3.1593E-02
    4 11    2.9750E-02   2.7573E-01   3.1593E-02
    5  6    2.9750E-02   2.7573E-01   3.1593E-02
    6 11    2.9751E-02   2.7573E-01   3.1593E-02
    7  2    2.9751E-02   2.7573E-01   3.1593E-02
    8  6    2.9751E-02   2.7573E-01   3.1593E-02
        A0                     A1                     A2               RMS ERROR (MPH)
  0.27573043E+00      0.0                     0.27521397E-03          0.1725E+00
 1CASE       F             Y-F     STANDARD                VARIABLES
                                   DEVIATION
                                   OF ESTIMATE
     1     56.22992       0.00008     0.00000       0.0            56.23000
     2     52.94400       0.48599     0.02044       3.00000        53.42999
     3     49.93327      -0.20328     0.03515       6.00000        49.73000
     4     47.16125      -0.22125     0.04532       9.00000        46.94000
     5     44.59694      -0.10693     0.05187      12.00000        44.49001
     6     42.21481       0.01518     0.05555      15.00000        42.23000
     7     39.99316      -0.04317     0.05697      18.00000        39.95000
     8     37.91359       0.13641     0.05664      21.00000        38.05000
     9     35.96028       0.03972     0.05504      24.00000        36.00000
    10     34.11964      -0.08965     0.05258      27.00000        34.03000
    11     32.37990       0.15010     0.04974      30.00000        32.53000
    12     30.73079       0.03922     0.04702      33.00000        30.77000
    13     29.16330       0.05670     0.04498      36.00000        29.22000
    14     27.66953       0.04048     0.04423      39.00000        27.71001
    15     26.24249       0.03751     0.04525      42.00000        26.28000
    16     24.87601      -0.01601     0.04830      45.00000        24.86000
    17     23.56453      -0.04453     0.05332      48.00000        23.52000
    18     22.30313      -0.22313     0.06005      51.00000        22.08000
    19     21.08734      -0.20734     0.06816      54.00000        20.88000
    20     19.91319       0.26680     0.07737      57.00000        20.17999
    21     18.77702       0.02298     0.08746      60.00000        18.80000
0ITERATION       ERROR       PARAMETERS
   NO.   SHF     MEAN
                 SQUARE

    0  0    3.5639E+00   2.9190E-01   2.5500E-02
    1  0    7.8648E-02   2.6970E-01   2.9916E-02
    2  0    5.9234E-02   2.7527E-01   2.9589E-02
    3  0    5.9226E-02   2.7526E-01   2.9595E-02
    4  0    5.9224E-02   2.7526E-01   2.9595E-02
    5  0    5.9224E-02   2.7526E-01   2.9595E-02
    6  2    5.9221E-02   2.7526E-01   2.9595E-02
    7 11    5.9221E-02   2.7526E-01   2.9595E-02
    8  0    5.9221E-02   2.7526E-01   2.9595E-02
        A0                     A1                     A2               RMS ERROR (MPH)
  0.27525908E+00      0.0                     0.24108347E-03          0.2434E+00
 1CASE       F             Y-F     STANDARD                VARIABLES
                                   DEVIATION
                                   OF ESTIMATE
     1     57.66986       0.00014     0.00000       0.0            57.67000
     2     54.56741      -0.29741     0.02649       3.00000        54.27000
     3     51.70068      -0.24068     0.04605       6.00000        51.46001
     4     49.04063      -0.32063     0.06001       9.00000        48.72000
     5     46.56282      -0.43282     0.06943      12.00000        46.13000
     6     44.24652       0.00348     0.07515      15.00000        44.25000
     7     42.07391       0.07608     0.07791      18.00000        42.14999
     8     40.02962       0.21039     0.07831      21.00000        40.24001
     9     38.10039      0.44962     0.07689     24.00000     38.55000
    10     36.27464      0.04536     0.07417     27.00000     36.32001
    11     34.54228     -0.00229     0.07067     30.00000     34.53999
    12     32.89442      0.11557     0.06696     33.00000     33.00999
    13     31.32312      0.35687     0.06368     36.00000     31.67999
    14     29.82146     -0.19145     0.06154     39.00000     29.63000
    15     28.38321      0.06679     0.06125     42.00000     28.45000
    16     27.00284      0.03716     0.06335     45.00000     27.03999
    17     25.67535     -0.43535     0.06804     48.00000     25.24001
    18     24.39630     -0.01630     0.07518     51.00000     24.38000
    19     23.16159     -0.30159     0.08444     54.00000     22.86000
    20     21.96759      0.07240     0.09543     57.00000     22.03999
    21     20.81093      0.13907     0.10781     60.00000     20.95000
    22     19.68860      0.07140     0.12132     63.00000     19.75999
0ITERATION     ERROR    PARAMETERS
 NO.   SHF     MEAN
               SQUARE

     0  0    4.2740E+00  2.9190E-01  2.5500E-02
     1  0    3.8803E-01  2.3316E-01  3.3621E-02
     2  0    4.3093E-02  2.4368E-01  3.3406E-02
     3  0    4.2994E-02  2.4392E-01  3.3397E-02
     4  1    4.2993E-02  2.4392E-01  3.3397E-02
     5  5    4.2992E-02  2.4392E-01  3.3397E-02
     6 11    4.2994E-02  2.4392E-01  3.3397E-02
     7  0    4.2994E-02  2.4392E-01  3.3397E-02
     8  0    4.2993E-02  2.4392E-01  3.3397F-02
        A0                       A1                      A2               RMS ERROR (MPH)
 0.24391907E+00      0.0                       0.27205842E-03           0.2073E+00
1CASE        F              Y-F    STANDARD                  VARIABLES
                                   DEVIATION
                                   OF ESTIMATE
     1     54.69989      0.00011     0.00000      0.0          54.70000
     2     51.66109      0.46892     0.02420      3.00000      52.13000
     3     48.86823      0.25177     0.04174      6.00000      49.12000
     4     46.28976     -0.06976     0.05397      9.00000      46.22000
     5     43.89900     -0.27901     0.06194     12.00000      43.62000
     6     41.67366     -0.01366     0.06650     15.00000      41.66000
     7     39.59476     -0.00476     0.06835     18.00000      39.59000
     8     37.64603      0.08397     0.06809     21.00000      37.73000
     9     35.81351     -0.08351     0.06627     24.00000      35.73000
    10     34.08508      0.20491     0.06340     27.00000      34.28999
    11     32.45024     -0.18024     0.06002     30.00000      32.27000
    12     30.89980     -0.04979     0.05676     33.00000      30.85001
    13     29.42566      0.11433     0.05428     36.00000      29.53999
    14     28.02068      0.19933     0.05331     39.00000      28.22000
    15     26.67851     -0.22852     0.05448     42.00000      26.45000
    16     25.39357     -0.22357     0.05810     45.00000      25.17000
    17     24.16083      0.19917     0.06411     48.00000      24.36000
    18     22.97575     -0.26575     0.07221     51.00000      22.71001
    19     21.83434      0.15567     0.08201     54.00000      21.99001
    20     20.73288      0.23712     0.09315     57.00000      20.97000
    21     19.66809     -0.11809     0.10536     60.00000      19.55000
0ITERATION     ERROR    PARAMETERS
 NO.   SHF     MEAN
               SQUARE

     0  0    3.8629E+00  2.9190E-01  2.5500E-02
     1  0    6.2401E-02  2.7266E-01  2.9820E-02
     2  0    4.7710E-02  2.7960E-01  2.9338E-02
     3  0    4.7679E-02  2.7955E-01  2.9350E-02
    4  0     4.7678E-02   2.7955E-01   2.9350E-02
    5  0     4.7677E-02   2.7955E-01   2.9350E-02
    6  0     4.7677E-02   2.7955E-01   2.9350E-02
    7  3     4.7677E-02   2.7955E-01   2.9350E-02
    8  2     4.7677E-02   2.7955E-01   2.9350E-02
         A0                     A1                     A2              RMS ERROR (MPH)
  0.27554924E+00         0.0                  0.24080717E-03          0.2184E+00
 ICASE       F               Y-F   STANDARD               VARIABLES
                                   DEVIATION
                                   OF ESTIMATE
    1      57.33990        0.00009    0.00000      0.0           57.34000
    2      54.25327       -0.00327    0.02372      3.00000       54.25000
    3      51.39954        0.25046    0.04126      6.00000       51.64999
    4      48.75015        0.05984    0.05378      9.00000       48.81000
    5      46.28108        0.00891    0.06224     12.00000       46.28999
    6      43.97175       -0.07179    0.06739     15.00000       43.89999
    7      41.80470        0.31529    0.06988     18.00000       42.12000
    8      39.76474        0.23526    0.07025     21.00000       40.00000
    9      37.83870        0.15131    0.06899     24.00000       37.99001
   10      36.01520        0.14481    0.06656     27.00000       36.16000
   11      34.28418       -0.03418    0.06344     30.00000       34.25000
   12      32.63689       -0.11688    0.06011     33.00000       32.52000
   13      31.06548       -0.28548    0.05716     36.00000       30.78000
   14      29.56306       -0.11307    0.05524     39.00000       29.45000
   15      28.12347       -0.27347    0.05496     42.00000       27.85001
   16      26.74126       -0.12126    0.05683     45.00000       26.62000
   17      25.41142       -0.13142    0.06103     48.00000       25.28000
   18      24.12955       -0.31955    0.06745     51.00000       23.81000
   19      22.89162       -0.28162    0.07576     54.00000       22.61000
   20      21.69357        0.29604    0.08564     57.00000       21.99001
   21      20.53328        0.22672    0.09677     60.00000       20.75999
   22      19.40654        0.38345    0.10891     63.00000       19.78999
0ITERATION      ERROR        PARAMETERS
  NO.   SHF     MEAN
                SQUARE

    0  0     6.4093E+00   2.9190E-01   2.5500E-02
    1  0     3.4664E-02   2.8072E-01   3.0007E-02
    2  0     2.4749E-02   2.9095E-01   2.9194E-02
    3  0     2.4605E-02   2.9086E-01   2.9219E-02
    4  0     2.4602E-02   2.9087E-01   2.9219E-02
    5  6     2.4602E-02   2.9087E-01   2.9219E-02
    6  6     2.4602E-02   2.9087E-01   2.9219E-02
    7 11     2.4602E-02   2.9087E-01   2.9219E-02
    8  1     2.4602E-02   2.9087E-01   2.9219E-02
    9 11     2.4603E-02   2.9087E-01   2.9219E-02
         A0                     A1                     A2              RMS ERROR (MPH)
  0.29086876E+00         0.0                  0.24832925E-03          0.1569E+00
 ICASE       F               Y-F   STANDARD               VARIABLES
                                   DEVIATION
                                   OF ESTIMATE
    1      57.12991        0.00009    0.00000      0.0           57.13000
    2      53.95993        0.22006    0.01805      3.00000       54.17999
    3      51.03517        0.21483    0.03122      6.00000       51.25000
    4      48.32465        0.18535    0.04047      9.00000       48.50999
    5      45.80254       -0.01254    0.04655     12.00000       45.78999
    6      43.44690        0.06310    0.05008     15.00000       43.50999
    7      41.23901       -0.02901    0.05158     18.00000       41.21001
    8      39.16280        0.26720    0.05147     21.00000       39.42999
    9      37.20430        0.00571    0.05017     24.00000       37.21001
   10      35.35146       -0.10146    0.04806     27.00000       35.25000
  11      33.59375     -0.08376      0.04554     30.00000     33.50999
  12      31.92188     -0.17188      0.04307     33.00000     31.75000
  13      30.32768     -0.18768      0.04116     36.00000     30.14000
  14      28.80396     -0.21396      0.04038     39.00000     28.59000
  15      27.34427      0.16573      0.04121     42.00000     27.50999
  16      25.94287     -0.14287      0.04391     45.00000     25.80000
  17      24.59462     -0.17462      0.04845     48.00000     24.42000
  18      23.29491      0.16510      0.05461     51.00000     23.46001
  19      22.03955      0.05045      0.06209     54.00000     22.09000
  20      20.82475      0.07524      0.07063     57.00000     20.89999
  21      19.64708      0.14291      0.08001     60.00000     19.78999
0ITERATION     ERROR      PARAMETERS
  NO.   SHF    MEAN
               SQUARE

    0  0    4.5445E+00   2.9190E-01   2.5500E-02
    1  0    1.1154E-01   2.7294E-01   2.9924E-02
    2  0    9.4479E-02   2.8118E-01   2.9334E-02
    3  0    9.4423E-02   2.8110E-01   2.9353E-02
    4  1    9.4419E-02   2.8110E-01   2.9352E-02
    5  2    9.4418E-02   2.8110E-01   2.9352E-02
    6  3    9.4414E-02   2.8110E-01   2.9352E-02
    7 11    9.4426E-02   2.8110E-01   2.9352E-02
    8  0    9.4425E-02   2.8111E-01   2.9352E-02
    9  0    9.4420E-02   2.8111E-01   2.9352E-02
   10  0    9.4415E-02   2.8111E-01   2.9352E-02
   11  4    9.4415E-02   2.8111E-01   2.9352E-02
   12  5    9.4415E-02   2.8111E-01   2.9352E-02
          A0                     A1                         A2           RMS ERROR (MPH)
   0.28110522E+00       0.0                      0.24218272E-03     0.3073E+00
1CASE          F     .        Y-F   STANDARD                VARIABLES
                                    DEVIATION
                                    OF ESTIMATE
   1      58.21994      0.00006      0.00000      0.0         58.22000
   2      55.04742      0.47258      0.03362      3.00000     55.52000
   3      52.11908      0.21092      0.05839      6.00000     52.33000
   4      49.40442      0.29558      0.07602      9.00000     49.70000
   5      46.87793      0.07207      0.08787     12.00000     46.95000
   6      44.51788      0.33212      0.09504     15.00000     44.85001
   7      42.30576      0.30424      0.09846     18.00000     42.61000
   8      40.22559      0.47441      0.09890     21.00000     40.70000
   9      38.26360      0.02640      0.09705     24.00000     38.28999
  10      36.40773     -0.26773      0.09358     27.00000     36.14000
  11      34.64757     -0.46758      0.08914     30.00000     34.17999
  12      32.97388     -0.12387      0.08444     33.00000     32.85001
  13      31.37849     -0.46849      0.08031     36.00000     30.91000
  14      29.85425     -0.20425      0.07763     39.00000     29.64999
  15      28.39474     -0.10475      0.07729     42.00000     28.28999
  16      26.99425     -0.52425      0.07997     45.00000     26.47000
  17      25.64763      0.19237      0.08590     48.00000     25.84000
  18      24.35030     -0.16029      0.09493     51.00000     24.19000
  19      23.09810      0.19189      0.10660     54.00000     23.28999
  20      21.88722      0.17278      0.12045     57.00000     22.06000
  21      20.71426      0.17574      0.13604     60.00000     20.89000
  22      19.57610      0.29390      0.15304     63.00000     19.87000
0ITERATION     ERROR      PARAMETERS
  NO.   SHF    MEAN
               SQUARE

    0  0    9.6585E+00   2.9190E-01   2.5500E-02
    1  0    1.1852E-01   2.6220E-01   3.1960E-02
    2  0   1.9701E-02   2.7689E-01   3.0960E-02
    3  0   1.8996E-02   2.7680E-01   3.1006E-02
    4  0   1.8996E-02   2.7680E-01   3.1006E-02
    5  4   1.8996E-02   2.7680E-01   3.1006E-02
    6  4   1.8996E-02   2.7680E-01   3.1006E-02
    7 11   1.8996E-02   2.7680E-01   3.1006E-02
    8  0   1.8996E-02   2.7680E-01   3.1006E-02
        A0                         A1                         A2            RMS ERROR (MPH)
   0.27679682E+00        0.0                       0.26609795E-03      0.1378E+00
1CASE        F              Y-F    STANDARD                 VARIABLES
                                   DEVIATION
                                   OF ESTIMATE
    1     59.60995       0.00005     0.00000
    2     56.10869      -0.02869     0.01573       0.0           59.61000
    3     52.90785       0.19215     0.02709       3.00000       56.08000
    4     49.96642      -0.02641     0.03500       6.00000       53.10001
    5     47.25065      -0.00069     0.04018       9.00000       49.94000
    6     44.73244      -0.10243     0.04319      12.00000       47.25000
    7     42.38786       0.09213     0.04449      15.00000       44.63000
    8     40.19681       0.13319     0.04446      18.00000       42.48000
    9     38.14201      -0.12201     0.04343      21.00000       40.33000
   10     36.20871      -0.17871     0.04172      24.00000       38.02000
   11     34.38402      -0.07402     0.03963      27.00000       36.03000
   12     32.65685      -0.09689     0.03749      30.00000       34.31000
   13     31.01752       0.19249     0.03566      33.00000       32.56000
   14     29.45740      -0.07739     0.03455      36.00000       31.21001
   15     27.96856       0.04103     0.03452      39.00000       29.38000
   16     26.54556       0.02444     0.03583      42.00000       28.00999
   17     25.18124       0.22876     0.03857      45.00000       26.57001
   18     23.87071       0.08929     0.04262      48.00000       25.41000
   19     22.60921      -0.25920     0.04779      51.00000       23.96001
   20     21.39244       0.21756     0.05387      54.00000       22.35001
   21     20.21654      -0.14653     0.06068      57.00000       21.61000
   22     19.07800      -0.03801     0.06808      60.00000       20.07001
                                                  63.00000       19.03999
```

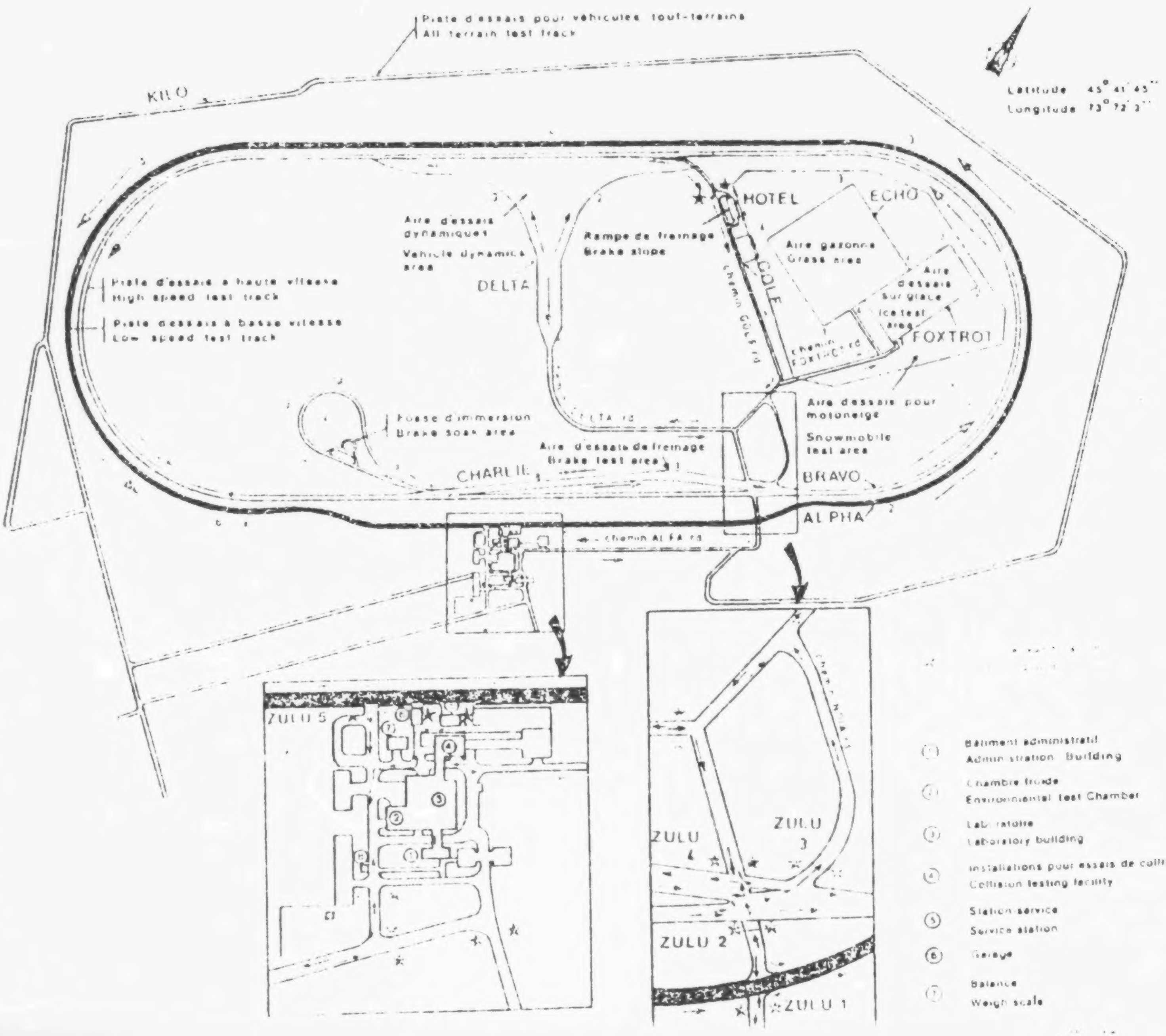
REGRESS

```
0.26337594E+00   0.0            0.24495507E-03   0.1930E+00
0.25566071E+00   0.0            0.26255939E-03   0.1610E+00
0.27332145E+00   0.0            0.24735089E-03   0.1901E+00
0.27573043E+00   0.0            0.27521397E-03   0.1725E+00
0.27525908E+00   0.0            0.24108347E-03   0.2434E+00
0.24391907E+00   0.0            0.27205842E-03   0.2073E+00
0.27954924E+00   0.0            0.24080717E-03   0.2184E+00
0.29086876E+00   0.0            0.24832925E-03   0.1569E+00
0.28110522E+00   0.0            0.24218272E-03   0.3073E+00
0.27679682E+00   0.0            0.26609795E-03   0.1378E+00
```

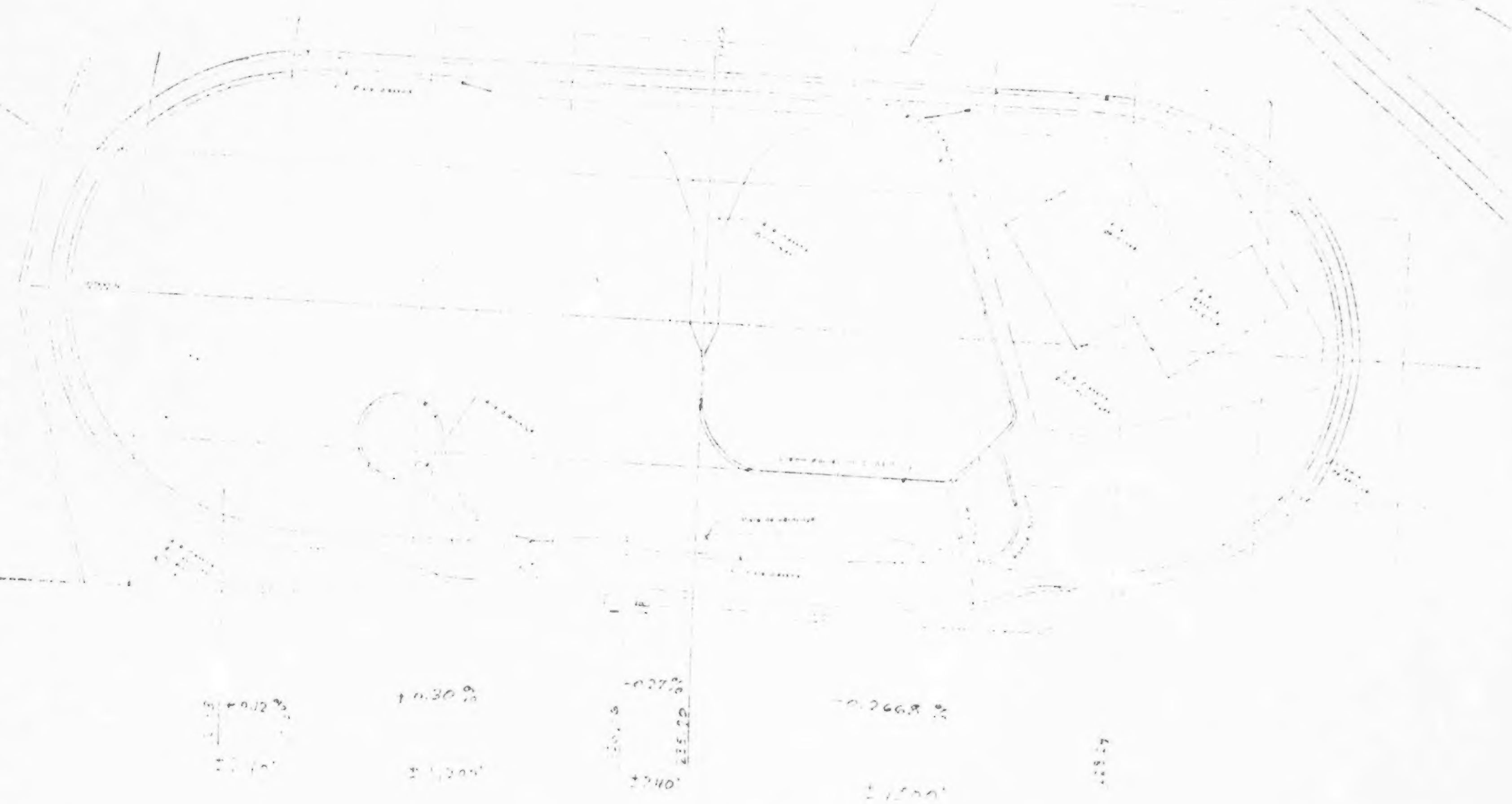
TRACK LAYOUT

ANNEX D

APPENDIX D1


Piste d'essais pour véhicules tout-terrains
All terrain test track
KILO
Latitude 45° 41' 45''
Longitude 73° 72' 2''
HOTEL
ECHO
Aire gazonnée
Grass area
Aire d'essais sur glace
Ice test area
FOXTROT
Chemin FOXTROT rd
GOLF
Chemin GOLF rd
Aire d'essais dynamiques
Vehicle dynamics area
Rampe de freinage
Brake slope
DELTA
Piste d'essais à haute vitesse
High speed test track
Piste d'essais à basse vitesse
Low speed test track
Fosse d'immersion
Brake soak area
Aire d'essais de freinage
Brake test area
DELTA rd
CHARLIE
Aire d'essais pour motoneige
Snowmobile test area
BRAVO
ALPHA
Chemin ALFA rd
ZULU 5
ZULU 4
ZULU 3
ZULU 2
ZULU 1
① Bâtiment administratif
Administration Building
② Chambre froide
Environmental test Chamber
③ Laboratoire
Laboratory building
④ Installations pour essais de collision
Collision testing facility
⑤ Station-service
Service station
⑥ Garage
⑦ Balance
Weigh scale

APPENDIX D2


+0.12 %
±
+0.30 %
± 1,200'
-0.27%
±240'
235.22
-0.2668 %
± 1,500'

APPENDIX 12

PROCEDURE FOR CALCULATING PERCENTAGE CHANGE IN CITY CYCLE FUEL CONSUMPTION ON A PER BAG BASIS WITH RESPECT TO THE BASE CONFIGURATION

CALCULATION PROCEDURE FOR PERCENTAGE CHANGE IN FUEL CONSUMPTION ON A PER BAG BASIS

The data shown in Tables 20-22 (Volume 1) summarizes the average fuel consumption (in litres/100 km) for all configurations tested. As discussed in Section 3.4, this data was calculated using the following equations:

$$\text{Fuel Consumption } (\ell/100\text{ km}) = \frac{\text{Fuel consumed (grams)} \times 144.686^{*}}{\text{Accumulated roll revs} \times \text{specific gravity}} \; {}^{+}$$

For the City Cycle:

Fuel consumed (gm):

$$= \left[0.43 \times (\text{bag } 1)\right] + \text{bag } 2 + \left[0.57\ (\text{bag } 3)\right]$$

and accumulated roll revolutions:

$$= \left[0.43 \times (\text{bag } 1)\right] + \text{bag } 2 + \left[0.57\ (\text{bag } 3)\right]$$

Overall fuel consumption changes in percent form for the city cycle (as shown in Tables 25, 30 and 39, Volume 1) were calculated using the following equation:

Overall % change =

$$\frac{\left[\text{Fuel Consumption } (\ell/100\text{ km})\right]_{\text{Base}} - \left[\text{Fuel Consumption} (\ell/\text{km})\right]_{\text{Modified}} \times 100\%}{\left[\text{Fuel Consumption} (\ell/\text{km})\right]_{\text{Base}}}$$

*Unit Conversion Constant

+ Specific Gravity = .7003 (Section 2.3)

As indicated by the previous expression, positive valves signify a decrease in fuel consumption over the base value. For the purpose of breaking down this change on a per bag basis (Tables 26, 31 and 40, Volume 1), the following expressions were used:

% improvement in Bag 1 =

$$\frac{\left[\text{Fuel Consumption over Bag 1}\right]_{\text{Base}} - \left[\text{Fuel Consumption over Bag 1}\right]_{\text{Modified}}}{\left[\text{Fuel Consumption over Bag 1}\right]_{\text{Base}}}$$

% improvement in Bag 2 =

$$\frac{\left[\text{Fuel Consumption over Bag 2}\right]_{\text{Base}} - \left[\text{Fuel Consumption over Bag 2}\right]_{\text{modified}}}{\left[\text{Fuel Consumption over Bag 2}\right]_{\text{Base}}}$$

% improvement in Bag 3 =

$$\frac{\left[\text{Fuel Consumption over Bag 3}\right]_{\text{Base}} - \left[\text{Fuel Consumption over Bag 3}\right]_{\text{Modified}}}{\left[\text{Fuel Consumption over Bag 3}\right]_{\text{Base}}}$$

Because of the bag weighting procedure in calculating overall city cycle fuel consumption, the individual % improvements on a bag basis cannot be directly combined to yield the % improvement in fuel consumption for the complete city cycle.

POOR
QUALITY
ORIGINAL